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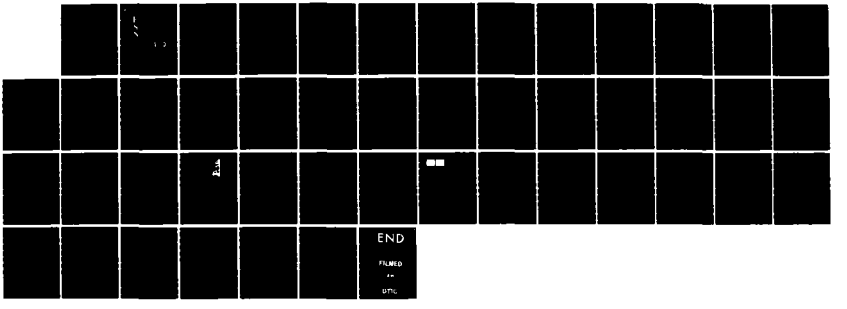

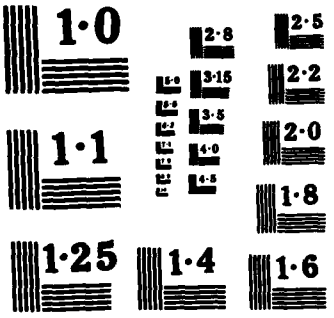

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European Science Notes (ESN) is a monthly publication with brief articles on recent developments in European scientific research. The publication is not intended to be part of the scientific literature. The value of ESN articles to Americans is to call attention to current developments in European science and technology and to the institutions and people responsible for these efforts. ESN authors are primarily ONRL staff members. Occasionally articles are prepared by or in cooperation with staff members of the USAF European Office of Aerospace Research and Development or the US Army Research, Development and Standardization Group. Qualified US scientists travelling in Europe may also be invited to write an ESN article.

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Biological Sciences

The organizational development and in-progress work of this German research institute is reviewed. The work covered includes research in microbiology, enzyme technology, cell biology and genetics, and biotechnology methods. The collaborative efforts with universities and industry have made this institute a leader in the transfer of research to industry.

This article reviews the work in progress at this center for biotechnology and the cooperative efforts which promise to create a major biotechnology center.

The Seventh European Immunology Congress was held in Jerusalem from 8 through 13 September 1985. Of particular interest, as judged by attendance at the various sessions, were the reports dealing with the areas of immunology research that are being given increasing attention by scientists: interferons, interleukins, immunoregulation, neural and endocrine interactions with the immune system, immunodeficiency, immunomodulation, and immunopharmacology.

The first international congress and exhibition for biotechnology, Biotechnica '85, took place from 8 through 10 October 1984 in Hannover, West Germany. It covered three general areas: measurement, process control, and development of models; preparation, use, and improvement of biocatalysts; and animal and plant cell cultures.

A group of scientists interested in cavitation produced by medical ultrasound have formed a research collaboration in the UK. This article provides background on clinical ultrasound and cavitation, and describes the experiments being considered by the research team.

Chemistry

The workshop covered by this article provided presentations of interest to several related disciplines: reaction energy transfer and advanced diagnostics, and mechanisms of energetic reactions.

Earth Sciences

A large share of Israeli research in geophysics is devoted to oil and gas exploration and recovery of oil from shale. Of special interest are the on-going investigations in fragmentation of materials.

Material Sciences

Paisley College of Technology, Scotland, has a rapidly growing program in fiber-reinforced composites. Researchers here are particularly interested in assessing impact damage of composite structures.

New developments in the field, as well as progress reports of ongoing research were presented at the annual meeting of the International Institute of Welding. Commission IX of the Institute is responsible for welding research that is associated with the behavior of metals subjected to welding. The documents arising from this commission's work include official definition of terminology, weld metal hydrogen cracking, and assessment of the state of the art on reheat cracking in steel welds; these documents and progress reports are highlighted here.

Many research projects are in progress at Finland's primary metallurgical research center, including projects in semiconductor metallurgy, superconducting materials, and computer-aided alloy developments.

Physics

A brief review of an AGARD meeting held 23 through 27 September, in Istanbul, is given. This successful and pleasant conference covered the areas of fiber optic sensors, fiber optic communications, tactical lightwave technology, novel types of fibers, and various other devices and techniques.

News and Notes

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* * *

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Biological Sciences

BIOTECHNOLOGY RESEARCH AT GBF, WEST GERMANY

by Claire E. Zomzely-Neurath. Dr. Zomzely-Neurath is the Liaison Scientist for Biochemistry, Neurosciences, and Molecular Biology in Europe and the Middle East for the Office of Naval Research's London Branch Office. She is on leave until July 1986 from her position as Director of Research, the Queen's Medical Center, Honolulu, Hawaii, and Professor of Biochemistry, University of Hawaii School of Medicine.

Background--The Organization, Functions, Goals

The Gesellshaft für Biotechnologische Forschung (GBF) is one of the 13 German research institutes committed exclusively to research in biotechnology. Professor J. Klein, the present director of GBF, has been instrumental in developing GBF into probably the top biotechnology research institute in West Germany. It was started in 1976 with support from the Volkswagen Foundation as an institute for molecular biology research. Currently, the Federal Ministry of Research and Technology provides 90 percent of GFB's support and the state of Lower Saxony provides the remainder. GFB is now carrying out a broad program of research and development in the field of biotechnology, using microorganisms, plant and animal cell cultures, and isolated enzyme systems. Areas covered include: isolation, separation, and purification of natural products; genetic engineering to produce microorganisms of biotechnological interest; methods for obtaining biochemicals for industrial use or metabolites for use as basic materials in the pharmaceutical and food industries; bioreactor design and process control for the mass culture of microorganisms and higher cells; and related fundamental studies. Klein states that two aspects have to be considered for any GBF project: pursuit of new products and procedures, and basic research (with its inherent risk of working on projects that may take 10 to 20 years to come to fruition, if ever).

The GBF also participates in joint projects with other institutions and organizes symposia, lectures, and experimental courses.

There are 249 permanent positions in the scientific divisions and the corresponding infrastructure with a total staff today of 390. The budget for 1985 totals 36.7 million DM ($14 million). The organization chart is shown in Figure 1.

The Deutsche Sammlung von Mikroorganismen (DSM), or German Collection of Microorganisms, is part of the Institute for Biotechnological Research (GBF). The main functions of DSM are (1) to collect, maintain, and preserve authentic cultures of living microorganisms relevant for applied microbiology, biotechnology, education, and those of general scientific interest; (2) to provide information on microorganisms of the collection by publishing annual catalogs and supplements; (3) to supply cultures to clients within or outside Germany; (4) to serve as an international depository for microorganisms cited in patent applications; (5) to offer special scientific services; (6) to offer training facilities and to provide advisory and consultation services on enrichment, isolation, identification, and preservation of microorganisms; and (7) to conduct research on collection-related matters and on taxonomy. Special scientific services DSM provide include: (1) safe deposit (long-term maintenance of microorganisms which remain the property of the depositor); (2) freeze-drying (preparation of freeze-dried cultures for clients); and (3) identification of bacteria, yeasts, and fungi (excluding pathogenic microorganisms) to generic or species level, determination of DNA base composition, and chemotaxonomy. DSM is a member of the World Federation for Culture Collections (WFCC) and cooperates with other service culture collections.

Research Projects at GBF

Microbiology. An important goal of this project is the search for new antibiotics. Since the discovery of penicillin more than 50 years ago, almost 7000 other antibiotics have been isolated from various microorganisms. Unfortunately, only a small number have found practical application in human and veterinary medicine, agriculture, or as animal feed additives or preservatives. Penicillin itself was chemically modified to give the potent ß-lactam antibiotics of the second and third generation of today. However, there are still a large number of possible applications which are insufficiently covered, if at all, by the present-day antibiotics. Among them are, for example, fungal and viral infections, tropical diseases, resistant bacteria, and pest control. For

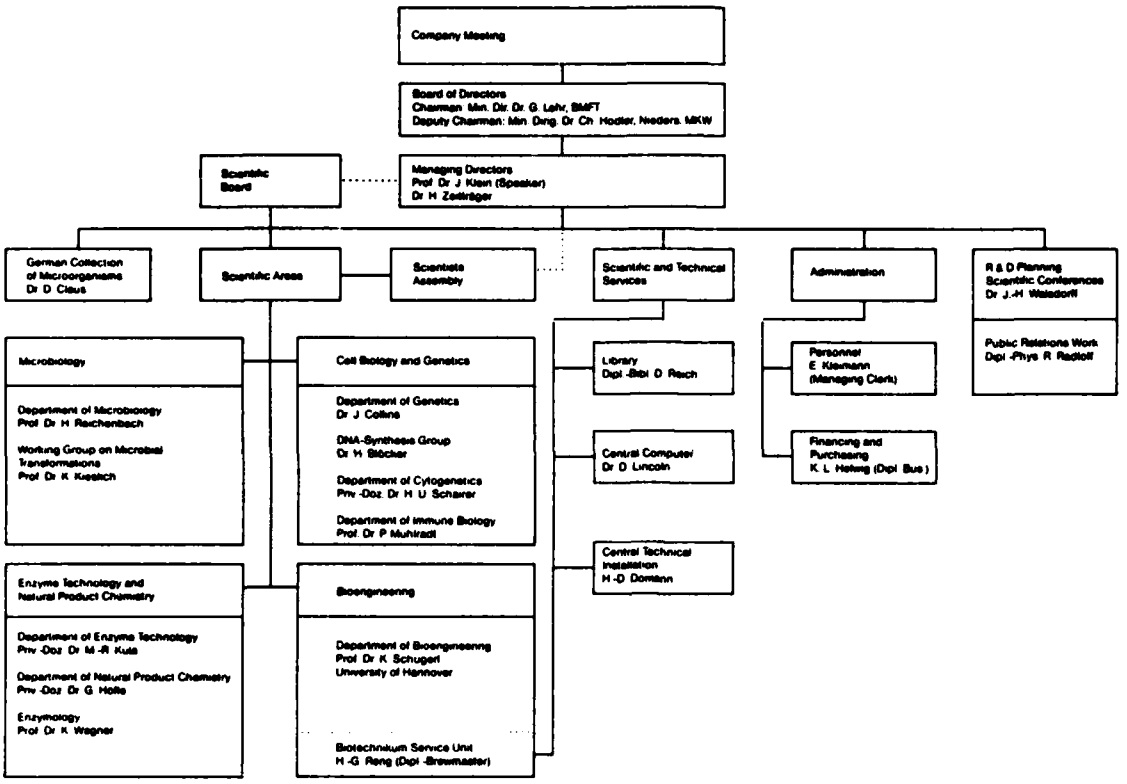

Figure 1. The GBF organization

this reason, the search for new natural products with antibiotic or pharmacological activity is being pursued vigorously at GBF. Their search, or screening, either concentrates on special groups of microorganisms or on the application of sophisticated test systems.

During a GBF screening project it was found that many myxobacteria which are common soil organisms form antibiotics. Selected strains were cultivated up to the 4000-liter scale and the antibiotics produced were extracted from bacterial cells or the culture medium. Their chemical structures were elucidated by spectroscopic and chemical methods. A few of these biologically active components are (1) myxothiazol from *Myxococcus fulvus*--active against fungi, including yeasts and insects; (2) stigmatellin from *Stigmatella aurantiaca*--active against fungi, including yeasts; (3) Myxovirescin, from *Myxococcus virescens*--active against gram negative bacteria; and (4) corallopyronin from *Corallococcus coralloides*--active against bacteria.

Until now, more than 60 different compounds have been isolated. They can be assigned to four new structural types: macrolides, polyethers, heterocyclics and modified peptides. They show high specificity, in some cases at a level of only 2 ng/ml against various bacteria, fungi, viruses or insects. Some act as specific inhibitors of bacterial RNA polymerases or enzymes of the respiratory chain and have found application in biomedical research. Further applications of isolated as well as chemically modified compounds are currently being investigated at GBF.

Another direction in microbiology is the search for new enzymes which have industrial application. Of 300 enzymes known today, only 10 can actually be used. Therefore, not only is there an ongoing search for new enzymes but also for enzymes with defined characteristics for defined purposes.

Enzyme Technology. The goal in this area is to develop new methods or to improve existing methods for the isolation and large-scale production of biologically active proteins such as enzymes. In addition, basic research is being carried out to find ways to use enzymes

technically; for example, to regenerate coenzymes.

One of the projects which is pursued vigorously at GBF is continuous enzyme recovery by crosscurrent extraction. The extractive recovery of intracellular microbial enzymes in aqueous two-phase systems is usually carried out discontinuously by two to three subsequent single-stage extraction stages. With such a procedure only two unit operations are necessary , as generally found in extraction technology: (1) mixing, followed by phase dispersal, and (2) phase separation. Both operations can be performed continuously without difficulty. Therefore, a high potential exists for carrying out these processes continuously, according to the principles of crosscurrent extraction, with advantages of high space time yield, low labor costs, and short residence times. Several such processes have already been studied at GBF. Figure 2 shows the flow scheme of the process. The cells are disrupted by wet milling and, after they pass through a heat exchanger, polyethylene glycol (PEG) and salts are added into the process stream of broken cells. After mixing and equilibration, the phase system is separated, the outflowing (or bottom-phase) going to waste. The product-containing PEG-rich top phase goes to a second mixer after addition of salt solution to the process stream. After a second separation, the product leaves in the bottom phase, while the PEG-rich top phase goes to waste or is recycled. Measurement and control techniques include online monitoring of product concentration and quality. A computer is used for overall process control. On a plant scale, the average throughput is about 100 l/h. A capacity of 120 t of biomass per year can be calculated for a biomass concentration of 25 percent and a net process time of 200 days per year.

Another project actively pursued at GBF is improvement of the production of amino acids, which constitute an important market in many areas. Researchers at GBF have been able through development of new enzymes and coenzyme-regeneration systems to increase the efficiency of amino acid production at the industrial level.

Cell Biology and Genetics. This scientific division is involved in the development of new recombinant DNA methods and the application of these methods to biotechnological problems. Within Germany, the largest share of state funding for recombinant DNA research through direct institutional support goes to this division. The aim of the recombinant DNA method is to reconstruct

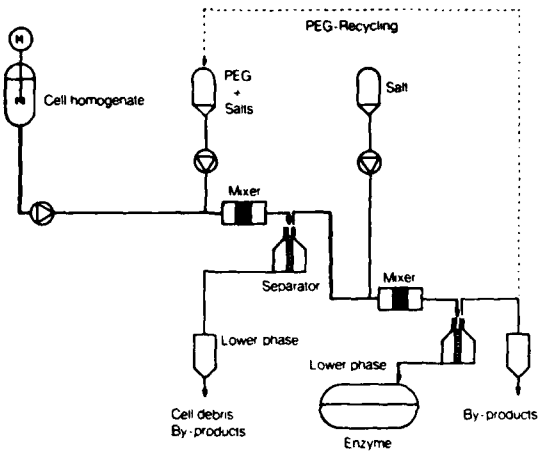

Figure 2. Flow scheme for enzyme recovery by continuous crosscurrent extraction.

the genes of bacteria, fungi, or animal cells in such a way that specific products are produced in large quantities. In addition, the molecular basis of disease, cancer, normal development, and ageing can be studied on a more detailed level with these methods.

The main objectives of research at GBF are (1) to produce substances not available in sufficient quantities for clinical tests (e.g., human interferon, parathyroid hormone and other hormone-like peptides); (2) to replace conventional chemical processes which are too unspecific, too poisonous for the environment, or too expensive, by developing improved enzyme catalyzed processes (e.g., the use of penicillin acylase for the production of semi-synthetic penicillins); and (3) the elucidation of the structure of dangerous pathogens (e.g., cytomegalo virus, other herpes viruses, or gonorrhea)--this could lead directly to the development of new vaccines against these diseases.

A prerequisite for the application of recombinant DNA (rDNA) methods is the investigation of basic techniques and biological relationships. For this reason, new rDNA methods are constantly being developed (e.g., the cosmid cloning system developed at GBF). At present, it represents the best method for the isolation and cloning of large DNA pieces from chromosomes.

The Genetics Department also incorporates special units for the production of monoclonal antibodies for application in the area of clinical diagnostics, for hormone purification, and for the chemical synthesis of oligodeoxyribonucleotides.

Some of the results of the research by the cell biology and genetics department at GBF are:

1. Construction of super-producing Penicillin-acylase bacteria strains (1978 world-wide first application of the rDNA technique to a biotechnological process).
2. Development of new methods for isolating human genes: recombination-screening with cosmids, and a mouse cell bank containing human-cosmid hybrids for application in the "cosmid-shuttle" method; e.g. isolation of human thymidinekinase gene and interleukin-2 genomic clones.
3. Identification of the DNA sequence of the human fibroblast interferon gene control region using the cloned interferon gene. Direct transformation of the mouse cell lines with this cloned DNA yields transformed mouse cells producing high amounts of human fibroblast interferon. This is also the first example of a human gene controlling its own production in foreign cells. Human interferon, naturally produced in the human body, protects human cells against virus infections. In addition, the human fibroblast interferon as well as other interferon species are presently being investigated as potential anti-cancer drugs in clinical trials.
4. Development of an *E. Coli* strain producing high levels of human fibroblast interferon.
5. Development of a radically new method for the simultaneous synthesis of hundreds of oligodeoxyribonucleotides (segmental support system). This allows total synthesis of complete genes (e.g., ß-interferon variants).
6. Identification and isolation of four new human genes, which, as well as interferon, are turned on following virus infection.
7. Cloning of total cytomegalo virus (225 Kbases; i.e., 100-fold larger than foot and mouth disease virus) in collaboration with Professor B. Fleckenstein (University of Erlangen). This has led to the first detailed physical characterization of the virus.
8. Cloning and expression of the human parathyroid gene. Parathyroid hormone from the parathyroid gland regulates the calcium level in the blood. Investigation of a future possible application for the treatment of osteoporosis is also planned when sufficient amounts of the hormone become available.
9. Isolation and characterization of a DNA segment that gives higher efficiency translation of attached genes (e.g., ß-interferon at 14 percent and interleukin-2 at 20 percent of the total protein).

Biotechnology Methods. A new technology for bubble-free tissue culture aeration based on open pore hydrophobic membranes has been developed at GBF. Foam formation must be avoided in tissue culture reactors to prevent flotation of cells, proteins, and microorganisms. The oxygen supply to the cells necessary for growth and respiration as well as the homogenization of the nutrient solution can be performed completely bubble-free with the application of open pore hydrophobic membranes. The main element is a moving clew or basket consisting of membrane tubes. The membranes are made from polypropylene with a porous asymetric structure. The pore volume constitutes 70 percent; the average pore width is 0.33 µm. The hydrophobic characteristics of the membrane resist penetration by water up to 5 bar pressure, enabling the formation of a gas-liquid interface layer directly on the face of the membrane in contact with the liquid. Material transport in both directions is thereby facilitated across the interface without a diffusion barrier. The membrane tube through-flow enhances both oxygen and CO_2 exchange in the reaction zone (see Figure 3). The tumble number and the gas through-flow rate enable control over transport capacity to meet actual cell requirements. This technology has been implemented in 1 l, 20 l and 70 l reactors. Continuous tissue cultivation of genetically manipulated mouse fibroblasts over many months has proven the applicability of this technology for the production of recombinant human ß-interferon.

A research project on the processing of waste water, containing starch, to butanol and acetone was carried out in a collaborative project between the GBF and Emslandstarke GmBH, Emlichheim. The starch was initially broken down to sugar with the addition of technical amylase at 80°C and a pH value of 6.5. Subsequently, the hydrolysate was fermented using *Clostridium acetlbutylicum* DSM 792. Prior sterilization was not necessary. The pH value was initially adjusted to 4.2 and did not require any further adjustment during fermentation. A 2-stage fermentation plant was used for the process. The solvents produced can be enriched using decanol extraction (a volume ratio of 1:3 decanol to culture filtrate is used) which is recovered by distillation at 95 to 100°C. Fermenter 1 consisted of a product-inhibited chemostat and capillary shaped module for culture activation through degasification and formation of increased

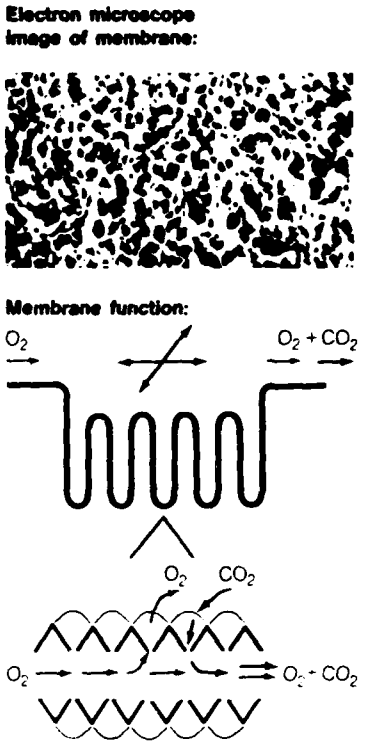

Figure 3. Bubble-free tissue culture aeration based on open pore hydrophobic membranes.

microturbulence. Fermenter 2 consisted of continuous culture with cell feedback and regulation of turbidostatic cell concentration. A cell concentration of 1 to 18 g/l dry cell matter can be achieved in this system.

GBF also has an excellent biotechnical facility for large-scale preparation using fermentors of up to 100 liters. GBF is also working on the development and use of microprocessors and process calculators for use in monitoring product separation and harvesting. They have initiated, as well, a project in protein engineering to change the structure of proteins in a goal-oriented direction or to construct new proteins to specification.

Partnership With Industry

Collaboration with industry is important for GBF. It is interested in furthering research so that it can offer interesting projects and solutions of problems which can be used by industry in the development of new biotechnical methods. Fast transfer of new methods and technologies is assured by means of a broad and active collaboration. GBF licenses its know-how to industry and obtains some income from this source as well as from the patents on products and methods developed at GBF.

GBF is also fostering collaborative projects with universities at Hannover, Braunschweig, Jülich, and Göttingen. GBF was originally part of the University of Braunschweig and still retains an affiliation with the university. In this respect, GBF and the university are planning a new course in biotechnology, within the framework of the natural sciences, and in biomethodology, within the engineering sciences. The scientists of GBF are involved in this planning and will, if they are not already, be part of the teaching staff of the university.

Conclusion

According to Professor Klein, Director of GBF, biotechnology is the application of biological systems for technical uses, and the problems can be worked on successfully only if approached in an interdisciplinary way. Therefore, the spectrum of the sciences represented at GBF spans the spectrum from natural sciences to engineering sciences. Under the direction of Klein, GBF has developed in a very short time into a major biotechnology facility in Germany. The research at basic and applied levels is excellent and has already brought international recognition to the scientists at GBF. The collaborative projects developed with other universities and with industry have already made GBF a leader in the transfer of research from the university to industry.

11/25/85

BIOTECHNOLOGICAL ACTIVITIES OF THE INSTITUTE OF TECHNICAL CHEMISTRY, UNIVERSITY OF HANNOVER, WEST GERMANY

by Claire E. Zomzely-Neurath.

The Institute of Technical Chemistry/The University of Hannover is recognized as one of the major institutes in West Germany having active research programs in biotechnology. It is directed by Professor Karl Schügerl, who has been instrumental in developing biotechnology research at the basic and applied levels.

Background

Research in the field of biotechnology at the institute began 15 years

ago. At that time two projects were carried out: enzyme engineering, in cooperation with Boehringer Mannheim, Tutzing; and single cell protein (SCP) production in cooperation with Gesellschaft für Biotechnilogische Forschung, Braunschweig--i.e., Institute for Biotechnology Research (GBF). With respect to the former project, an enzyme membrane reactor was developed and scaled up for the separation of L-amino acids from racemate mixtures. Later on, the cooperative partners were changed to Degussa and GBF (M. Kula). The latter project was extended later to coenzyme systems with cofactor regeneration by Degussa, GBF (M. Kula), and KFA Jülich (C. Wandrey). In the frame of the SCP project, an airlift tower loop reactor was developed and modelled in cooperation with the Institute of Automatic Control of the University of Hannover and with the GBF (F. Wagner). After the importance of measurement, modelling, and control for biotechnology was recognized, a project was started in collaboration with the Institutes of Microbiology and Automatic Control to develop the hardware and software for online process analyses, data acquisition, structured cell growth models, their implementation on a process computer, and state estimator for adaptive control cultivation. This system was adapted to the cultivation of *Saccharomyces cerevisiae* and ethanol production.

Research Projects

In cooperation with the Institute of Microbiology a project was started to improve the secondary metabolite production by *Penicillum chrysogenum* by means of a pellet morphology and airlift tower loop reactors. The necessary specific power input was reduced from 4 to 5 kW/m^3 to 0.8 kW/m^3. The specific penicillin production with respect to cell mass, power input, and substrate were significantly higher than with filamentous mycel. A new technique has been developed for the recovery of Penicillin A and V from the fermentation broth which is based on ion pair extraction. Using this extraction and conventional extraction columns, the extraction and reextraction is carried out at 20°C and pH 5 to 7 with a loss of penicillin--due to decomposition--amounting to less than one percent. This is in comparison with the loss of 15 to 20 percent of the commercial process carried out at 5°C and pH 2--thus, an excellent result.

The present investigation in the field of product formation can be divided into five groups: (1) cell mass production (bacteria, yeasts and fungi), (2) primary metabolite production (ethanol, acetone) and butanol by yeasts and bacteria, (3) secondary metabolite production (Penicillin G and V, Cephalosporin C), (4) enzyme production (cellulases and penicillin acylase), and (5) animal tissue cultures production (*Spodoptera fungiperdo*) for insect virus production.

The downstream process activity covers: (1) foam flotation of cells and proteins, (2) reactive extraction of metabolites, and (3) membrane separation of cells and proteins.

Enzyme engineering research is concentrated on the development of second generation enzyme reactors, especially enzyme liquid membrane reactors with cofactor regeneration. The institute researchers are also investigating α and γ interferon production in suspended cultures in collaboration with the Blood Service of the German Red Cross. These activities of the institute are mainly directed towards the production, separation and purification of pharmaceutical products.

Research is also being carried out to upgrade wastes for use as renewable resources. These projects are: (1) conversion of lignocellulose into fungus cell mass (*Chaetomium celluloyticum*) for animal feeding or for glucose, ethanol, and acetone/butanol production and (2) conversion of waste starch into fodder yeast and ethanol. In addition, reaction engineering aspects of enzyme production with genetically modified bacteria are also being studied.

The development of the institute's new physical, chemical, and biochemical methods and their use for on-line process analysis and control is still one of the main activities of the institute. This covers automated medium analysis as well as on-line characterization of two-phase systems and reactor behavior by means of the ultrasonic Doppler method, pseudorandom signal, and cross-correlation techniques. One of the main interests is the analysis of intracellular components by use of a microfluorimeter, laser flow cytometer, enzyme thermistor, and dye-targeting. In collaboration with the Institutes of Automatic Control and Neurobiology of the University of Hannover, a general computer operational system has been developed for data acquisition and evaluation, and for process control.

The 8 years of close cooperation between the Institutes of Microbiology, Technical Chemistry, and Automatic Control is unique in West Germany. In the future, this cooperation will be extended to other biotechnological research groups at the University of Göttingen

and the Technical University of Braunschweig as well as at GBF, Braunschweig, and industry to form a biotechnology center in Lower Saxony with the support of the federal and local government.

Conclusion

Biotechnology research at the Institute of Technical Chemistry, University of Hannover, encompasses a wide range of projects at both the basic and applied levels and is of excellent caliber. Several processes are being patented and collaborative programs with industry have been initiated. Under the direction of K. Schügerl the present and future collaborative projects with other biotechnology groups in Lower Saxony are aimed at instituting a major biotechnology center in this area.

11/25/85

7TH EUROPEAN IMMUNOLOGY CONGRESS, JERUSALEM, ISRAEL

by Claire E. Zomzely-Neurath.

The seventh European Immunology Congress was held in Jerusalem at the Binyanei Ha'ooma Convention Center from 8 through 13 September, 1985. About 1100 scientists from 27 countries participated in the intensive and impressive variety of sessions at the conference. Most of the attendees were from the UK, Europe, and Israel, although there were a fair number from the US as well. The number of presentations was dominated by France and Israel, reflecting the increasing emphasis on immunology research in these countries. Surprisingly, countries such as Poland, Hungary, and Yugoslavia were represented by an average of 16 presentations per country, indicating an increasing commitment to immunology research. Sixty-five exhibitors from Israel, Europe, the UK, and the US displayed scientific equipment and products geared to the field of immunology research.

The meeting covered a wide range of topics and consisted of symposia and colloquia (see Table 1) as well as 30 workshops. The workshops consisted of discussions of the poster presentations (590) in the various categories outlined in Table 1.

Of particular interest, as judged by attendance at the various sessions, were the reports dealing with the areas of immunology research that are being given increasing attention by scientists: (1) interferons, (2) interleukins, (3) immunoregulation, (4) neural and endocrine interactions with the immune system, (5) immunodeficiency, (6) immunomodulation, and (7) immunopharmacology.

It was evident at this conference that European scientists are making important contributions in all possible aspects of immunology research.

Table 1

Format of the 7th European Immunology Congress

Opening Plenary Session (Chairman, M. Sela, Israel)

Structure and functional analysis of class II MHC molecules. H.O. Mc Devitt, US.

The role of cloned lymphokines in B cell activation. G. Nossal, Australia.

Symposia

Molecular biology, genetics, and function of MHC

T-lymphocytes-antigen receptors and effector functions

Immunology and immunomanipulation of tumors

Organization and regulated expression of immunoglobulin genes

T- and B-cells--surface markers, regulation, and differentiation

Gene cloning in immunology (antigens, receptors, and lymphokines)

Autoimmune disorders and new approaches to their control

Colloquia

Interferons and interleukin-2

AIDS

Immunoregulatory circuits; idiotypes, T-cells, and surface receptors

Antigen presenting cells and molecular events in antigen processing

Pathogenic mechanisms in autoimmunity

Oncogenes

Immunomodulation and immunopharmacology

Macrophages as regulators of the immune response

MHC-genes

T-cell differentiation markers

Modulation of the anti-tumor immune response

Immunobiology of viral infections

Molecular aspects of T-cell cytoxicity

Bone marrow transplantation

Chemical aspects of macrophage functions

MHC and Ig genes and their products

B- and T-cell markers and their functions

Human anti-tumor immune response

Hybridomas in basic and applied immunology

Immunopharmacology

Transplantation immunity

Allergic responses--triggering and mediating

Immune regulation by interferons

MHC and other antigens on the cell surface of tumor cells

New therapies for autoimmunity

Immunobiology of parasitic infections

B-cell differentiation factors

For a detailed account of the congress, see ONR, London, report C-12-85, which you can order by filling out the return mailer inside the back cover of this issue.

11/1/85

BIOTECHNICA '85: FIRST INTERNATIONAL CONGRESS FOR BIOTECHNOLOGY

by Claire E. Zomzely-Neurath.

The first international congress and exhibition for biotechnology, Biotechnica '85 took place from 8 through 10 October, 1985 in Hannover, West Germany. The meeting was designed to provide insight into the structure and growth potential of this relatively new market. The biotechnology congress focused on the commercial and industrial applications of biotechnology. It combined extensive exhibitions, seminars, workshops, and panel discussions. Because of the emphasis on fostering contacts between industry and academics, the congress received support from the European Economic Community (EEC). Over 170 companies, research institutes, and universities from 15 countries disseminated information about current developments in research, laboratory equipment, and production techniques.

The topics in the scientific program presented at the symposia sessions were divided into three general areas: (1) measurement, process control, and development of models; (2) biocatalysts--preparation, utilization, and improvement; and (3) animal and plant cell cultures. Details about the format for these sessions are shown in Table 1.

A US seminar on biotechnology, held concurrently with the scientific sessions, was geared to representatives from industry. It was sponsored jointly by the US Department of Commerce, the Foreign Commercial Service Association of Biotechnology Companies (ABC), and the Industrial Biotechnology Association (IBA). These sessions were designed to acquaint European companies with US regulations on biotechnology products and potential problems for distribution of European biotechnology products in the US. The topics covered are listed in Table 2.

There were also sessions by company representatives from the US, UK, West Germany, and The Netherlands in which special services and equipment were described and applications discussed on the basis of questions from the audience. Some examples are: (1) Charles River Biotechnical Services, Inc.,

Table 1

Format of Sessions

Measurement, Process Control, Development of Models
Position paper on bioprocesses modeling and control
The recent state and future developments on biosensors
Principles of Modeling
Adaptive control principles and applications to biotechnical processes
Process models and their evolution
Control strategies for biological processes
Computer applications in the biotechnological industry
Some topics on computer aided operation of biochemical reaction processes
Computer based management of biotechnical processes
Biocatalysts: Preparation, Utilization, and Improvement
Recovery of biologically active proteins
Protein enrichment and purification
Affinity chromatography
Enzyme and cell immobilization
Biosynthesis by enzymes
Enzyme-catalyzed processes in organic solvents
Immobilized biocatalyst technology for peptide antibiotic production
Enzyme engineering
Animal and Plant Cell Cultures
Animal cell culture including monoclonal antibody production
New methods in animal breeding: implications for agriculture
An animal cell culture system for production of biologicals
Producing human interferon by recombinant mouse cells
The industrial production of monoclonal antibodies in cell culture
Plant molecular biology: implications for agriculture
Transfer and regulation of expression of chimeric genes in plants
Biotransformation
Plant cell cultures

Table 2

US Seminar on Biotechnology

- FDA regulating concerns about biotechnology-derived drugs and biologies
- US industry concerns about FDA regulation of biotechnology-derived drugs and biologies
- FDA regulatory concerns about monoclonal antibody *in vitro* diagnostic devices
- US industry concerns about FDA regulation of monoclonal-based *in vitro* diagnostic devices
- How foreign firms should interact with FDA in developing biotechnology products

US--industrial-scale purification of monoclonal antibodies for diagnostic and therapeutic applications; (2) Danon Biotech, Inc., US and Denmark--method for microencapsulation of living cells for large-scale production of cell proteins and *in vitro* encapsulation; (3) Ventrex Inc., US--Cellift™, a new idea for laboratory cell culture scale-up; (5) Miles-Kali-Chemie, West Germany--combined action of enzyme and metal catalyst applied to the preparation of mannitol; (6) Deutsche Pharmacia Gmb, West Germany (branch of Pharmacia, Sweden)--customer designed affinity media, fast-flow Sepharose; (7) Hartmann and Brown, West Germany,--continuous on-line gas analyses and regulation of fermentation processes. Concurrent sessions concerning marketing and venture capital, entitled "Biotechnology Financial Forum," were geared to the participants from small industrial companies and to those interested in founding biotechnology companies in liaison with research institutes.

There were about 2500 attendees at the Biotechnica '85, with at least half being representatives from industry, either from technical or marketing departments. The balance were research scientists from universities and research institutions engaged in biotechnology research or interested in expanding into this area.

The information presented in the scientific sessions consisted, in part, of a review of a particular area and was geared to newcomers to the field of biotechnology. However, recent research dealing with specific problems that have been solved--or that are in the process of being solved--as well as potential applications for industrial products were also presented. The reports on topics such as enzyme and cell immobilization, enzyme engineering by site-directed metagenesis, downstream processing of biologically active proteins, the use of animal cell cultures in the production of biologicals as well as several sessions on plant molecular biology reflected the top-level research being carried out by biotechnologists. The bulk of the presentations were from European laboratories.

For detailed information on this congress, see ONR, London, report C-13-85, which you can order by filling out the return mailer inside the back cover of this issue.

11/12/85

NEW TEAM EXAMINES ACOUSTIC CAVITATION GENERATED BY CLINICAL ULTRASOUND

by Lawrence A. Crum. Dr. Crum is Visiting Professor of Biophysics at Guy's Hospital Medical School, London, UK, where he is a Fulbright Research Fellow; he is currently on sabbatical from the Physical Acoustics Research Laboratory, Department of Physics and Astronomy, University of Mississippi, Oxford, Mississippi.

A group of scientists interested in cavitation produced by medical ultrasound have formed a research collaboration in the UK to combine their talents for a broad multidisciplinary study of the subject. The group is composed of scientists from the US, Oxford University, Cambridge University, Guy's Hospital Medical School, and the Institute for Cancer Research of the Royal Marsden Hospital. This article provides background on clinical ultrasound and cavitation, and describes the experiments being considered by the research team.

Clinical Ultrasound

Ultrasound is used principally in two ways in a clinical environment: (1) therapeutically--in which continuous wave or relatively lone pulses of ultrasound are used, mainly as a means of stimulating the repair of soft tissue injuries and relieving pain, and (2) diagnostically--in which extremely short pulses of ultrasound are used in an echo-ranging mode to form images of internal organs and tissues, mainly to enable an attending physician to make clinical decisions about further treatment.

Therapeutic ultrasound devices operate in the range of frequencies from about 0.75 to 3.0 MHz; are often driven in a continuous-wave (CW) mode, although pulsed operation with duty cycles of 1:1 and 1:4 are also common and utilize temporal peak acoustic intensities on the order of 1.0 W/cm^2. Diagnostic systems deliver considerably less power when the signal is time-averaged (say, 100 mW/cm^2, due to typical duty cycles of 1:1000), but have temporal peak intensities that often reach 1000 W/cm^2 (in terms of pressure units, this is approximately 5.5 MPa).

Since the threshold for acoustic cavitation inception can be less than 1.0 W/cm^2, there has always been a concern that these systems may induce cavitation *in vivo*.

What Is Cavitation?

In 1964, Flynn attempted to clarify the language concerning this complex phenomenon and defined cavitation to be

principally of two distinct types, stable and transient (Flynn, 1964).

Stable cavitation refers to the effects associated with the pulsation of a gas bubble that continues to oscillate for thousands of cycles. Although there may be acoustic streaming near the bubble, or it may grow toward (and through) its resonance size by a process called "rectified diffusion," this form of cavitation is considered to be primarily nonviolent and induces relatively minor mechanical effects.

In transient cavitation the negative acoustic pressure amplitude typically exceeds the ambient pressure and the bubble (or cavitation nucleus) quickly fills with vapor and grows rapidly in size during the negative portion of the acoustic cycle. The subsequent positive pressure portion of the acoustic cycle causes the bubble to collapse violently, with pressures and temperatures in the gas contained within the collapsed bubble reaching values of 1000 MPa and 10,000 K respectively. Further, asymmetric collapses can occur near boundaries, and high speed liquid jets develop that can cause extensive damage.

Application to Medicine

Although cavitation was recognized as a violent mechanism that could have serious consequences, it was not expected to occur in living tissue due to the presumed absence of the necessary cavitation nuclei. The theoretical tensile stress that a liquid can sustain is extremely high (on the order of 100 MPa for water). However, experimentally, water can sustain only a fraction of this value (0.5 MPa) because many liquids, especially water, possess numerous small stabilized pockets of gas that act as preferential sites for liquid rupture. If a liquid is treated or prepared in such a manner as to be free of these nuclei, it will approach its theoretical tensile strength (Apfel, 1981). Since living systems contain numerous filters (such as the lungs) that should remove these nuclei, it was presumed that acoustic cavitation would occur *in vivo* only at enormous negative pressure amplitudes. An important point, however, is that essentially every living animal will suffer decompression sickness or the "bends" if it is decompressed more rapidly than it can remove its supersaturated gas that is dissolved in the body tissues and fluids (Harvey et al., 1944). This rapid decompression will produce numerous bubbles that must arise from microscopic gas pockets that are present *in vivo* and have somehow been stabilized against dissolution. Even though these nuclei were recognized to be present, they were thought not to be activated acoustically due to the absence of any observed harmful side effects associated with the extensive use of clinical ultrasound.

Cavitation in Tissue

Since the late 1960s, M. Dyson and her colleagues at Guy's Hospital Medical School, London, have demonstrated that therapeutic ultrasound can have several beneficial effects. Among these are the stimulation of tissue regeneration, soft tissue repair, blood flow in chronically ischemic tissues, protein synthesis, and bone repair (Dyson, 1985). She has attributed these particular effects primarily to nonthermal origins--in that the application of an increased ambient pressure tends to reduce the beneficial results or eliminate them altogether. The best explanation for these effects is that there is an increase in the local circulation due to acoustic streaming associated with microscopic bubbles that are driven into pulsation by the applied sound field. In her studies, bubbles were never observed directly, but only inferred from the changes in behavior that occurred when the ambient pressure was increased.

In 1981, ter Haar and Daniels reported the observation of gas bubbles in the hind legs of live guinea pigs that were exposed to therapeutic ultrasound (ter Haar and Daniels, 1981). They used a diagnostic ultrasound device to scan the hind leg during irradiation with the therapeutic system and observed echoes characteristic of bubbles. They observed the production of numerous bubbles *in vivo* and found that the number increased rapidly with increased acoustic pressure amplitude of the applied ultrasound. Shortly thereafter, Crum and Hansen (1982) demonstrated that the bubble formation observed was consistent with a theoretical model based upon growth of microbubbles to visible size by rectified diffusion. These results suggested that therapeutic ultrasound could induce cavitation *in vivo*, but gave no indication as to potential dangers associated with the cavitation.

Flynn (1982) reported the results of some theoretical calculations that predicted that transient cavitation could result from the short (but large amplitude) acoustic pulses typical of diagnostic ultrasound scanners. Recently, Crum and Fowlkes (in press) have reported experimental confirmation of these predictions *in vitro*. They used a detection scheme based on the optical emissions from a collapsing cavitation bubble. The optical emissions are

important because they imply that highly reactive and potentially dangerous free radicals are produced during the collapse stage. It is the radiative recombination of these free radicals that produce light, a phenomenon commonly called sonoluminescence. The fact that this damage mechanism is the same as that produced by ionizing radiation makes a careful assessment of the degree and type of cavitation produced *in vivo* by clinical ultrasound machines--a subject of considerable interest.

A particularly efficient and sensitive technique for examining sonoluminescence has been developed by Walton and Reynolds (1984). Their system, which uses an image intensification technique, is particularly useful in that it gives both temporal and spatial resolution of the light emissions. They have used their system to study sonoluminescence from many types of acoustic cavitation.

Cavitation Team

Most of the scientists mentioned above have joined the research team at Guy's Hospital Medical School. The current composition of the team is as follows:

L.A. Crum, Department of Physics, University of Mississippi, US. Dr. Crum has been supported in the past by the Office of Naval Research, Arlington, Virginia, to study nonlinear bubble dynamics. He and A. Prosperetti of the University of Milan, a consultant to the research team, have developed a computer code that will be used to construct some mathematical models for cavitation inception.

S. Daniels, Physical Chemistry Laboratory, Oxford University. Dr. Daniels is an expert on decompression sickness and has developed a variety of experimental techniques to examine bubble production by decompression as well as by therapeutic ultrasound. He also has considerable knowledge of the role that nuclei play in the bubble growth process.

M. Dyson, Department of Anatomy, Guy's Hospital Medical School. Dr. Dyson was one of the first to examine in detail the many beneficial effects of therapeutic ultrasound. Her laboratory will be the host laboratory for Dr. Crum and for several of the experiments that will be attempted by the group. She and her staff will play an important role in the description of the biological effects of cavitation.

G. ter Haar, Institute for Cancer Research, Royal Marsden Hospital. Dr. ter Haar's collaboration with Dr. Daniels led to the seminal paper on acoustic cavitation *in vivo*. Recently, their collaboration has resulted in the development of a transparent gel that duplicates many of the *in vivo* results and permits extensive laboratory studies. Dr. ter Haar is currently a member of the European Committee for Ultrasound Radiation Safety (as is Dr. Dyson).

A.J. Walton, Cavendish Laboratory, Cambridge University. Dr. Walton has developed an image intensification technique (along with G. Reynolds of Princeton University, who will act as a consultant) for the examination of light emissions from acoustic cavitation. The author of a major review article on sonoluminescence, his experimental expertise will enable estimates to be made of the potential for damage associated with this form of cavitation.

Experiments in Progress

Several experiments are in the planning or progress stage:

1. Cinephotomicroscopic study of bubble growth in phantom materials by therapeutic ultrasound. In this project, an attempt will be made to measure the growth of cavitation bubbles in transparent phantom materials so that an applicable mathematical model can be constructed that will apply to the *in vivo* system.

2. Image intensifier studies of cavitation in phantom materials and *in vivo*. An experiment is planned whereby the image intensifier system will be used to view bubble formation and growth in a transparent gel and a transparent shrimp. If light emission is observed, identification of the nucleation site and microscopic examination of the cavitated area can be made.

3. Acoustic cavitation generated by diagnostic ultrasound generators. Preliminary evidence exists for bubble production in phantom materials by diagnostic scanners. A detailed study from both an experimental and theoretical basis will be made.

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11/7/85

Chemistry

ADVANCES IN CHEMICAL REACTION DYNAMICS

by Joyce Kaufman. Dr. Kaufman is in the Department of Chemistry at Johns Hopkins University.

Heavy American interest in research in disciplines relative to chemical dynamics was clearly in evidence at the NATO-sponsored workshop held in Iraklion, Crete, Greece, from 25 August to 7 September 1985. The director of the workshop, *Advances in Chemical Reaction Dynamics*, sponsored by the NATO Advanced Study Institute, was Peter M. Rentzepis of AT&T Bell Laboratories; co-director was Chris Capellos, of the Large Caliber Weapons System Laboratory, Aberdeen Research and Development Center (LCWSL, ARDC), Dover, New Jersey. Approximately 70 scientists from more than 12 countries attended the workshop. The conference could be divided into the following interrelated disciplines:

- Reaction dynamics,
- Spectroscopy and relaxation of intermediates,
- Energy transfer and advanced diagnostics,
- Mechanisms of energetic reactions.

Richard Bersohn, Columbia University, opened the conference with a two-lecture discussion of work carried out in his laboratory on internal and translational energy distribution in photodissociation of a number of molecules. First, some three atom systems were discussed and contrasted. These were $H+D_2 \rightarrow HD+D$ and $O(^1D)+H_2 \rightarrow OH+H$. This was followed by a series of reactions of $S(^1D)+OCS$ to give $S_2(X^3\Sigma)$, $S_2(^1A)$, and $S(^3P)$. Laser-induced fluorescence was used as an analytical tool. More complex systems such as fluorine atom reactions with methyl halides and translational energy release were examined in the photodissociation of iodonaphtalene, triazene, and styrene.

Two very stimulating papers were presented in the biochemical area. Joshua Jortner, Tel-Aviv University, reviewed the energetics and dynamics of excited states in large molecules and discussed dynamical aspects of primary photobiological processes. Electron transfer processes which are critical to understanding many processes in biology were treated in some detail both by Jortner and H. Kuhn, Max Planck Institut für Biophysikalische Chemie, Gottingen-Nikolausberg. Kuhn showed that coupled donor molecules separated by 15 to 20 Å produce electron transfer through paired charge carriers to acceptor molecules. Using appropriate donor-acceptor distances, barrier heights, tunneling, etc., he showed that major properties could be accounted for with simple quantum mechanical models. Kuhn also described some of his work on Langmuir-Blodgett monomolecular films. Here he could simulate donors and acceptors and vary their separation by using different fatty acids. This may prove to be a valuable tool in future work.

There were a number of other reports on energy transfer. Walter Koski, Johns Hopkins University, reported on electronic to translational energy transfers in positive halogen ion collisions with rare gas atoms. Bryan Henry, University of Manitoba, used gas phase overtone spectra of deuterated neo-pentanes as a probe of intramolecular vibrational energy redistribution.

Mostafa El Sayed, University of California, Los Angeles, reviewed his work on the detection of dipolar contribution to the mechanism of triplet-triplet energy transfer in molecular solids; he also reported on studies of rapid intramolecular and intra-ionic dynamic processes using two-color picosecond lasers and mass spectrometry.

A significant portion of the conference was devoted to properties and reactions of energetic compounds. W.

Byers Brown, University of Manchester, reported on a quantum statistical model on how pressure affects the activation barrier of reactions. Joyce J. Kaufman, Johns Hopkins University, presented her work on the theoretical prediction of crystal structures of energetic compounds; she also presented a paper on ab-initio CASSCF (complete active space multiconfiguration SCF) and MRD-CI (multireference determinant configuration interaction) calculations on the decomposition pathways of high energy compounds. Theoretical studies of the C_4 molecule, an important intermediate in explosion and combustion processes, were reported by James Ritchie of the Los Alamos National Laboratory. Ron W. Armstrong, University of Maryland, gave a description of how energy can be concentrated in solids by dislocation pile-up produced by shear. Experiments on laser-induced IR multiphoton decomposition of RDX crystals were described by L.A. Gamms of ARDC. Model calculations for a cooperative mechanism for shock-induced detonation waves in crystals of nitromethane were presented by Simone Odiot of the University of Paris. Major Scott A. Shackelford, European Office of Aerospace Research and Development (EOARD), London, reported on the use of the deuterium isotope effect to determine the rate determining step in the decomposition of a number of explosives. Steve C. Schmidt of Los Alamos National Laboratory outlined their efforts to study shocked liquids by Raman spectroscopy.

As might be expected, the majority of the experimental presentations involved the use of lasers in some form or another. One interesting chemical application was that reported by Dan Huppert, Tel-Aviv University, on geminate recombination in proton transfer reaction. In this approach a short duration laser pulse was used to excite an aromatic alcohol. This resulted in rapid proton dissociation. The proton, in turn, would then react with any sensitive species present in the solution. Rate constants could then be extracted for processes such as the geminate recombination. Vibrational relaxation of large molecules could also be studied by this technique.

Two very interesting laser applications were reported by George Atkinson, University of Arizona, the first on time resolved resonance Raman spectroscopy (TR^3) of liquid phase intermediates. State-of-the-art TR^3 spectroscopic methods employing a delay time between two laser pulses permit monitoring the results of scattering processes occurring on a 10^{-15} second time scale. In photochemical excitation of phenanthrene, vibrational spectra of excited states were employed to identify intermediate molecular species. In biological systems such as bacterial rhodopsin, molecular structural changes occurring on a picosecond time scale were revealed. The second presentation involved intracavity absorption laser spectroscopy. By using this technique one can realize an increase in sensitivity for absorption by a factor of 10^7. The sensitivity of the technique was illustrated by the detection of SiH_2 in SiH_4 in the production of amorphous silicon. The effective rotational (3°K) and vibrational (150°K) temperatures were determined from absorption spectra. This system could also be used to study collisions on weakly bound van der Waal's complexes and species such as I_2He, I_2Ar, and I_2Xe could be easily detected.

Howard Reiss, University of California, Los Angeles, reported on his studies on homogeneous gas phase polymerization of vinyl acetate using an apparatus similar to a Wilson cloud chamber. Helium was the carrier gas and a uv beam was used to promote polymerization. At sufficiently low light intensities only one polymer species was produced. The measurements permitted a determination of the rate of polymer growth as a function of light intensity.

Andre Persoons, University of Leuven, Belgium, reviewed the electric field effects in chemically reactive systems and then brought the conference up to the current state of the art. The effect of electric fields on equilibrium constants is small unless the field is high or the dipole is large. It will be recalled that in biopolymers the dipole moment can be in the thousands of Debyes. Although electric field effects on equilibrium constant, permittivity, etc., are small, careful work with modern instrumentation, which was described in some detail, revealed very interesting detailed information on dynamics of dipolar equilibrium, etc. The example of hydrogen bonding in phenol-amine pairs was cited. Equilibrium constants, dipole moments, rate constants, heat of reaction, etc., were determined.

Finally, three lectures by John H. Lee, McGill University, were of great appeal to those interested in combustion and turbulence. Again, the area was reviewed up to our current state of knowledge in the field. In attempting to answer the questions of how fast do reactants burn in a detonation and how fast do detonation waves move, two cases were discussed: (1) laminar flames where the mechanisms of propagation are diffusion of free radicals and heat and (2)

Chapman Jouget detonation. How detonation propagates is not known in detail. Turbulent flame speed is a function of initial and boundary conditions. In a tube, smoothness of wall as well as diameter play important roles. Conditions of initiation may also be important. Two other questions were also treated at this point. How do turbulence and shock waves influence burning rate and how are turbulence and shock generated by the flame? The influence of turbulence is to increase flame area and to increase local transport rate which, in turn, increase burning rate. Much more experimental and theoretical detail is needed. Shear is important in understanding the nature of turbulence which involves dissipation of energy from large eddies into small vortex tubes. The latter act like tornados in that they suck up free radicals and inject them into the burning region, resulting in a corresponding increase in burning rate. In connection with vortices and shock waves it was stressed that shock waves are not plane, as had been implied in earlier years, but rather that shock waves have a well defined cellular structure which can be easily demonstrated experimentally.

In discussing how laminar flames become turbulent, Lee cited eight mechanisms: hydrodynamic control, selective diffusion because of a molecular weight effect, thermal diffusion effects due to competition of mass and heat flow processes, acoustic control, Taylor instability due to density imbalances, Markstein instability due to curvature considerations, displacive flow due to volume imbalances, and Rayleigh instability. Although these processes have been studied individually and, in the main, understood, in real life cooperative effects between several processes operate simultaneously, and these are far from being understood. In discussing how detonation waves become turbulent and cellular, Lee cited an empirical breakthrough which permits one to predict initiation energy from detonation wave cell size. The critical cylindrical tube size to sustain detonation, d_c, is related to cell size, λ, by $d_c \approx 4\pi\lambda$.

In the final lecture, Lee reviewed experimental results on flame propagation and detonation in tubes. He pointed out that a continuous spectrum of propagation states exists between laminar burning controlled by diffusion and Chapman Jouguet detonation controlled by energetics. The state of turbulence prior to detonation appears to be controlling. Initiation may occur at hot spots associated with a critical vortex, and individual shocks may pile up to give rise to a very strong shock.

This conference was characterized by the high technical quality of the presentations and although the topics may appear to be diverse they all nicely blended into the conference theme--Chemical Reaction Dynamics. The directors and organizing committee are to be complimented on organizing this conference, which gave much to the beginner as well as to the seasoned investigator.

This conference summary was prepared with the assistance of Professors Ron W. Armstrong and Walter S. Koski and Major Scott A. Shackelford.

11/26/85

Earth Sciences

GEOPHYSICS RESEARCH IN ISRAEL

by Michael F. Shlesinger. Dr. Shlesinger is a Scientific Officer in the Physics Division, Office of Naval Research, Arlington, Virginia.

The Institute for Petroleum Research and Geophysics (IPRG) is the main center for geophysical research and exploration in Israel. Founded in 1952, it is located in Holon near Tel-Aviv and is staffed by 124 employees. Dr. Yair Rotstein, the Chief Scientist at IPRG, told me that the institute enjoys an affiliation with Tel-Aviv University, where several of its members teach in the Geophysics Department.

The IPRG operates a country-wide seismic network, does seismic research on the local and regional scale, and participates in a worldwide NASA program using satellite laser tracking to monitor global geodynamics.

A major effort of the IPRG is focussed on oil and natural gas exploration via seismology, although other methods such as magnetics, electromagnetics, and electrical resistivity are also used. The IPRG people employ large mobile stations which record the seismic reflections they induce. The complex scattered and time-delayed signals are processed and interpreted in-house, making extensive use of advanced computer software. Although no major

discoveries of oil have been made in Israel, oil as shale is plentiful.

A group led by Dr. Robert Englman and Dr. Zeev Jaeger at the Soreq Nuclear Research Center is investigating fragmentation of materials--in part to yield a more efficient recovery of oil from shale. They have organized a conference, *Fracture, Form, and Flow in Exploded Media*, for early 1986. Further information can be obtained from Dr. R. Englman, Soreq Nuclear Research Center, Yavne 70600, Israel; Telephone 08-484747, Telex: 341955. Topics included in the conference are geometry and topology of cracks and voids before blasting, the characterization and operation of commercial explosives, interrelations between rival fragmentation mechanisms and codes, size effects and scaling laws, particle size distribution, texture of fragmented media, and the validity of percolation models for flow in permeable structures. Recent work of the Soreq group has been in understanding the fragmentation of solids. Other members of the group include Y. Gui, M. Kushnir, A. Levi, Y. Putter, and A. Sprecher.

According to modern descriptions of the processes which cause the fragmentation of solid materials, it is the cracks that are initially present in the solid or are created in the process which are responsible for the fracture of the solid. They move about, grow, fork out, and coalesce under an applied stress, such as detonation, until fragmentation takes place. The motion of the cracks follows principles of fracture mechanics which specify the speed, direction, and duration of each individual crack, with dependencies on the properties of the medium and on the type, magnitude, direction, and time-variation of the applied stress. Even before the solid undergoes fragmentation because of crack-proliferation, its permeability becomes enhanced by the interconnected crack-network through which fluid can flow.

During the last 3 years some fashionable models of statistical physics have been put to use by the Soreq group with a view toward explaining permeabilities and fragmentation mechanisms in media pervaded by cracks. They have studied the percolation property of a two-dimensional network of randomly distributed narrow cracks (Englman et al., 1983). As the density of cracks in the sample increases, the likelihood of percolation across the specimen is obtained as a function of sample size. By extrapolation, the critical crack density of an infinite sample is found.

In a further study, also based on percolation theory, the distribution of fragment pieces was obtained (Englman et al., 1984). This study possesses some historical interest in that it relates to the use of the empirical Mott distribution function (the cumulative number of fragments decreases exponentially with their linear size) which was proposed by N.F. Mott during his war-time (1943) researches on mortar shells. Deviations from the Mott distribution in two and three dimensions by use of stereological methods were also found by the Soreq group (Gur et al., 1985).

The motion of between one single and ten independent cracks was stimulated in a recent work (Gur et al., 1985). The cracks are activated by a pressure wave emanating from a single borehole, or from an array of explosive boreholes. Pictures of crack trajectories show effects of the boundaries and of changes of stress from compressive to tensile type.

The methods of the Soreq group have so far been applied to oil shale mining but are equally relevant to ductile metallic materials (Slotky et al., (1985).

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11/25/85

Material Sciences

FIBER COMPOSITE RESEARCH AT PAISLEY COLLEGE OF TECHNOLOGY, PAISLEY, SCOTLAND

by Kenneth D. Challenger. Dr. Challenger is the Liaison Scientist for Materials Science in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until May 1986 from the Naval Postgraduate School, where he is Associate Professor of Materials Science.

Research on fiber-reinforced composites at Paisley College of Technology, Paisley, Scotland, is performed by a team led by Dr. Ian Marshall, Senior Lecturer, Mechanical Engineering Department.

Marshall began his research program on composites about 7 years ago. Since then, he has become increasingly prominent in the field of stability and damage analysis of fiber-reinforced composites. He is the editor of the international journal *Composite Structures*, has organized and edited the proceedings of two international conferences, organized the Third International Conference on Composite Structures held at Paisley in September 1985 (see *ESN* 40-1:21-24 [1986]) and was the co-chairman (with Dr. Andrzoi M. Brandt, Institute of Fundamental Technological Research, Polish Academy of Sciences) of the EUROMECH Colloquium, "Structure and Crack Propagation in Brittle Matrix Composite Materials" held in Warsaw, Poland from 11 through 15 November 1985.

The finite element analysis computer code PAFEC is used to analytically evaluate the effect of defects on the stress-strain behavior of fiber-reinforced composites. The researchers are analytically and experimentally examining defects such as inclusions (too much or too little resin), delaminations, and other flaws introduced by some form of impact damage.

At present, Marshall and his colleague, Dr. J. Paul, are studying two very practical topics associated with the design of structures using composite materials: the effect of geometric defects, such as a lack of flatness in sheet or plate; and the stability of composite plates with large perforations, such as access holes or "cutouts." The effect of geometric defects on buckling and the post-buckling response of plates to loading has also been analytically studied by others, but Marshall's experimental studies are unique. Large perforations are encountered in practically all engineering structures, yet very little attention has been given to the problem of analyzing these structures, even when standard materials of construction (for example, aluminum or steel) have been used.

The finite element code that they have used for the analysis of geometric defects has been further developed to include the ability to predict buckling and the post-buckling response of plates with large perforations.

Marshall's newest program is perhaps the most novel and interesting, the development of the DWT (double wallop test). This test is used to study impact damage to fiber reinforced laminated composites (FRLC). When a FRLC is impacted, there is damage in the form of matrix cracks, fiber cracks and, most importantly, interlaminar delamination. This delamination causes a very severe decrease in the compressive strength of the composite.

At present, the mechanisms of the formation and growth of the delamination are very poorly understood. There are no analytical models that can predict the type (size and shape) of impact damage as a function of the impactor characteristics, nor are there any analytical models to predict the effect of this damage on the residual strength of the component.

With a one-sided impact, the delamination is located closer to the side opposite the impact than to the impacted surface. Thus, any in-plane loads cause out-of-plane deformations, making the analysis very complicated. Consequently, Marshall has developed an experimental technique where a specimen is impacted simultaneously from both sides. Thus, identical surface damage will be created on each side, and the delamination will be at the midthickness location.

A number of different analytical approaches are being pursued to obtain an energy balance between the two aspects of the problem: macro-(energy of the impact) and micro-(energy absorbed as damage). It appears that a hybrid method of analysis which combines finite element analysis with empirical data is the most realistic way to analyze the problem.

Although the loading situation used in these experiments is unrealistic, perhaps they will be simple enough to allow the development of an analytical model. The design analysts need something that they have confidence in to be able to assess the damage. If

confidence in Marshall's model can be obtained, then perhaps it can be expanded to cover the more realistic situation of a single-sided impact.

Marshall's ideas are novel. This is exactly what is needed because impact damage has been accepted for years as the worst kind of damage in FRLCs and, to date, very little progress has been made toward understanding the mechanisms of the damage.

Concluding Remarks

The research on fiber-reinforced composites at Paisley College is growing rapidly under Marshall's leadership. His most important contributions will be in the fields of the damage tolerance of composites and the post-buckling behavior of large panels. His experimental testing facilities are being expanded as part of a laboratory expansion program at the college; approximately £500,000 have been provided to the Mechanical Engineering Department from the Scottish Education Department for this purpose. I expect that this growth will continue because Paisley College of Technology is one of only four engineering colleges in the UK that are directly funded by a government grant through the Scottish Education Department. These four colleges are called Central Institutions. Their funding through Scotland is noteworthy: because they receive their support directly from the Scottish government (not from London or their local boroughs, as do practically all other educational institutions in the UK). Also, the government is attempting to attract industry to Scotland, so Paisley College has been growing while most of the other education institutions in the UK have been suffering financial problems.

For information about other research on fiber composites in the UK, see Tsu-Wei Chou's series of articles in *ESN* 37-4 through 37-12, and his ONR, London, report R-6-83, *Composites Material Research in the UK: Assessment Report* (1983).

8/3/84

INTERNATIONAL RESEARCH ON THE PHYSICAL METALLURGY OF WELDING: A REVIEW

by Kenneth D. Challenger.

The annual meeting of the International Institute of Welding (IIW) was held in Strasbourg, France, last September. The IIW is divided into numerous commissions, each assigned responsibilty for a specific subject associated with welding. This article covers the meetings of Commission IX, of which I am a member.

Commission IX, is responsible for welding research associated with the behavior of metals subjected to welding. This includes the weldability of metals in relation to the welding process, the properties of the weldment, and testing methods to evaluate weldability. The commission's activities are very relevant to the US Navy's research on welding.

Metallurgy of Fused Weld Metal

Dr. R. Dolby (UK Welding Institute) presented IW document IX-1377-85. This document officially defines the IIW's terminology for steel weld metal microstructures. It is the result of exercises using photomicrographs and actual test specimens to examine and describe qualitatively the microstructure of these samples as viewed through a light microscope. The document is very useful for researchers in this area because there is considerable confusion over how various characteristics of steel weld metal microstructures are described.

A similar exercise is in progress to assess the best techniques for quantifying the characteristics of the macrostructures of steel weld metal. A report on this should be ready for the next IIW meeting, to be held in Tokyo in 1986. (Dolby is providing excellent leadership to the IIW on these topics.)

J. Vuik (Metaalinstituut TNO, Apeldoorn, The Netherlands) presented an excellent state-of-the-art review on the effect of carbon content on weld metal microstructure and properties of carbon-manganese (C-Mn) steels (IIW-IX-1375-85). He showed that as the carbon content increases, the yield and ultimate tensile strength increase at a rate of about 1000 Mpa/percent C. For notch toughness, both the C and the Mn content must be considered together. If the weld metal is to be stress relieved, the combination of low C and high Mn is best. When the carbon content exceeds 0.1 percent, the low temperature notch toughness decreases rapidly. Increasing C content results in increases in the amount of acicular ferrite and decreasing amounts of proeutectoid ferrite.

Another review paper (IIW-IX-1374-85), requested by Commission IX, on weld metal hydrogen cracking was presented by B. Graville (Welding Institute of Canada, Ontario). His review discussed the various types of tests used to assess hydrogen-induced cracking, the different

types of cracking that can occur, and the effects of composition and microstructure on the susceptibility of cracking. The review indicates that future work on this topic should focus on correlations of weld metal microstructure, chemical composition, and susceptibility to cracking (these correlations are much better understood for the heat-affected zone than for the weld metal); and on defining the minimum precautions necessary to avoid weld metal cracking.

With the US Navy's interest in copper bearing high-strength, low-alloy steels, a paper presented by S. Debiez (Institut de Soudure, French Welding Institute, Paris) is of considerable interest. Hardness, toughness, and hot and cold cracking have been evaluated for C-Mn steel weld metal with Cu contents of 0.04, 0.12, 0.47. 0.97, and 1.3 percent. The Cu content of 1.3 percent increased the hardness of the as-welded metal equivalent to a 50-Mpa increase in strength without any effect on toughness. Stress relieving at 600°C (step cooling) did not affect toughness nor was any evidence of embrittlement found. Strain aging was not altered by Cu. Implant tests have shown that the increased hardenability was insufficient to constitute a risk of cold cracking and the Varestraint test did not show any increased susceptibility to hot cracking.

Considerable interest in narrow-gap welding methods was expressed during the meeting. R.S. Chandel, et al. (Canada Center for Mineral and Energy Technology, Ottawa) presented a paper on the microstructure and mechanical properties of narrow gap welds in 2>Cr-1Mo steel; this paper is a good example of the type of research in progress on this process.

Chandel's group prepared experimental narrow gap welds (38-mm thick) by both submerged arc welding (SAW) and gas metal arc welding (GMAW) processes. Three different SAW welds were made using solid wire and three different fluxes (basicity index ranging from 1 to 3). A gap width of 15 mm with a 4-degree included angle was welded, using a two-pass-per-layer technique and a heat impact of 2 kJ/mm. The GMAW welds were made with a single pass, using a 12.7-mm gap width, Kobe twist wire, Ar-20%CO_2 shielding gas, and a heat input of 3.6 kJ/mm^2. All welds were post-weld heat treated at 690°C for 10 hours.

The results of many different tests on these welds show that the required toughness (54 J at -4°C) can be achieved only if the choice of welding consumables and welding operational parameters produces a fine bainitic microstructure with a low inclusion content (O_2+S<0.035%). Weld wires with S<0.01 percent and highly basic fluxes are necessary to produce this microstructure in SAW welds. For both processes (SAW and GMAW), heat inputs less than 4 kJ/mm will produce cooling rates that result in fine bainitic transformation products. Ductile fracture resistance was improved by reducing the inclusion content and brittle fracture resistance was improved by reducing the bainite packet size. In other words, the microstructural requirements for narrow gap welds are no different than any other welding process. The secret to sucessfully producing a good weld is understanding the relationships among the chemical components of the weld metal, the operational parameters, and the final weld metal microstructure.

A paper on high heat input SAW, a topic of high interest to the US Navy, was presented by M. Suzuki (IIW IX-1354-85). Two Ti microalloyed steels (low nitrogen content ∿0.008%) with 0.036% and 0.09% Al were welded with heat inputs ranging from 10 to 17 J/mm (900 to 1300 A) respectively. Their results show that with a neutral flux, Al content does not affect the ductile transition temperature; but with a highly basic flux, the Al is detrimental.

The topics for future efforts on the metallurgy of fused weld metal were proposed: (1) effects of phosphorus on the properties of steel weld metal; (2) post-weld heat treatment of microalloyed steels; (3) the quantity and distribution of small particles in weld metal; (4) effects of copper on weld metal properties; (5) reversible temper embrittlement; (6) the properties of weld metal deposited from metal cored wires; and (7) strain aging in weld metal.

Physical Metallurgy of Welding

M. Dadian (Institut de Soudure, Paris) has prepared a very thorough treatise on the physical metallurgy of steel welds. This was not presented as an official Commission IX document but issued as an Institut Soudure Report, Number 15726, April 1985. The report, explains how every aspect of physical metallurgy is required to understand welding. Dadian illustrates how the understanding of welding has contributed to the basic understanding of metallurgy in general. It is an excellent report, full of graphic illustrations explaining the effect of the operational welding parameters on solidification, segregation, and solid state transformations. At present, the report is published only in French.

A. Bragard (Centre Recherches Metallurgie, Belgium) and coworkers have developed a computer code to select the optimum welding operational parameters (such as heat input and preheating temperatures) to avoid cold cracking when given the specific chemical composition, weld geometry, and welding process. The code incorporates a model for heat flow (to predict the time spent between 800°C and 500°C and the time spent between 300°C and 100°C). Using this model, they find that the most critical parameter in determining the probability of cold cracking (hydrogen-assisted cracking) is the cooling time between 300°C and 100°C, because this determines the amount of hydrogen that can diffuse out of the weldment.

Drs. C. Duren and J. Degenkolbe (Mannesmann, West Germany) both presented results of research at Mannesmann to develop mathematical models to predict the microstructure resulting from specific welding operations and the subsequent hardness and susceptibility to cold cracking. This information was presented as diagrams of carbon equivalent (their own carbon equivalent, which has been used successfully by Shell International) versus the preheating temperatures required to avoid cold cracking. A considerable amount of research continues on the development of mathematical expressions to predict the hardness and cracking susceptibility of steel welds. Several different carbon equivalents were presented; it seems unlikely that any one empirical equation is going to be able to predict these parameters for all classes of steel.

Y. Komizo and colleagues (Nippon Steel, Japan) have studied the hardenability of boron-containing, low nitrogen (<5 ppm) steel and have developed a new formula for assessing the probability of hydrogen assisted cracking (cold cracking), Pcm. The important aspect of this research is that they have shown that the effect of B on Pcm is 23 times as great as carbon (on a weight percentage basis). Their expression for Pcm also includes a factor for Nb when it is present in excess of 0.05 percent.

Professor H. Hoffmeister (Hochschule de Bundeswehr, Hamburg, West Germany) and his students are doing some fine research on several different welding topics. He described the instrumented restraint cracking (IRC) test that they have developed to assess the hydrogen assisted cracking susceptibility of high strength offshore steels (IIW-IX-1369-85). The test is characterized by the continuous recording of the reaction forces and moments during the thermal cycle of a weld. Therefore, one can monitor the time for the onset and propagation of a crack as a function of the stress situation. It appears to be an excellent test for both weld procedure development and qualification.

I. Hrivnak (Czechoslovakian Welding Research Institute, Bratislava) presented some weldability results on a new class of steel alloys jointly under development in Czechoslovakia and the USSR. (See *ESN* 39-12:561-565 [1985]). These oxide dispersion hardened steels are reported to have excellent weldability.

One Commission IX objective for 1984 was to assess the state of the art on reheat cracking in steel welds. A. Dhooge and A. Vinckier (State University of Ghent, Belgium, (see *ESN* 39-8:375-378 [1985]) have been active researchers on this topic for several years. Their review is excellent and is published as IIW document IX-1373085. They have concluded that although the problem of reheat cracking has been largely solved, there are still some problems with reheat cracking in low- and high-alloy steels, hence a considerable research effort continues. Weld metal reheat cracking in 2>Cr-1Mo (where Cu has a very deleterious effect) and under-bead cracking of pressure vessel steels are the two remaining problem areas. Stringent control of the Cu content of the weld method (most researchers use non-Cu coated wires for SAW) and the use of welding processes that produce the finest possible grain size are necessary to avoid reheat cracking of 2>Cr-1Mo welds. Underbead cracks are caused by both hydrogen-assisted cracking and reheat cracking; these two different mechanisms of cracking have probably been confused in the past. Reheat cracking can be minimized by double pass cladding (causing grain refinement of the heat-affected zone created by the first cladding pass), restricting the impurity contents of the steel, and minimizing residual solidification segregation in areas close to the surface to be clad.

The mechanism of reheat cracking is understood; thermally induced embrittlement, such as secondary hardening and temper-embrittlement, are found to act together. Controversy still exists over the role of precipitates, especially MnS, that contribute to intergranular cavitation, and in turn lead to reheat cracking.

Most tests for the susceptibility to reheat cracking use either modified implant tests or Y-groove restraint tests on real and simulated weld heat-affected zones. It is necessary to study the cracking susceptibility throughout the entire post-weld heat treatment

(PWHT) and not just the maximum PWHT temperature because cracking has been found to occur during the heating stage of the PWHT cycle.

The final point made in Dhooge and Vinckier's review was that underclad cracks, if present, do not pose any threat to the pressure vessel integrity. This has been confirmed by fatigue crack growth tests and fracture mechanics analysis.

Another Commission IX objective for 1984 was to assess the state of the art on the influence of stress relief heat treatment. Working Group Chairman I. Hrivnak (Czechoslovakian Welding Institute, Bratislava) presented document IX-1359-85. The conclusion of this review is that stress relief heat treatments not only reduce residual stresses but also alter the microstructure; hence, the mechanical properties are affected. Various codes and standards for this heat treatment were reviewed. One potential problem area that becomes obvious as a result of this review is that none of the standards consider the type of weld metal used but specify the heat treatment only on the basis of the chemical composition and thickness of the welded component.

Commission IX members feel that the maximum thickness which does not need the obligatory heat treatment ranges from 20- to 50-mm thickness, depending on the code or standard. This should be reassessed.

Welding Stainless Steels and Nickel Alloys

A subcommission within Commission IX is studying the current topics in welding stainless steels and nickel alloys. These studies include cracking in fully austenitic-stainless and nickel-base welds. Document IX-H-145-85, by M. von Nassau, on the measurement of microfissures in these weld metals is currently undergoing review. A round-robin comparison of the method used by over 12 different laboratories to measure the microfissures in welds has begun.

A review paper on welding 2>Cr-1Mo steel to 16Cr-13Ni and 12Cr steel is being prepared and will be available at the Tokyo meeting next year.

Professor Hoffmeister's research group is also studying the effect of weld metal composition and welding conditions on delta-ferrite and charpy V-notch toughness of austenitic-ferrite weld metal. The cooling rates following welding and the chemical composition of the weld metal influence the delta-ferrite content; these, in turn, are responsible for stress-corrosion cracking resistance, notch-toughness, and strength. The group states that delta-ferrite/austenite continuous-cooling transformation diagrams should be used to determine the effect of cooling rate on the delta-ferrite contents.

The use of laser surface treatments to desensitize austenitic stainless steels was discussed by Y. Nakao and K. Nishimoto (Osaka University, Japan). Time-temperature-densensitization (TTDS) diagrams for Type 304 stainless steel were calculated, assuming that chromium diffusion limits the rate of the reaction. These calculations agreed quite well with corrosion tests (electrochemical potentiokinetic reactivation, EPR, technique and 0.10 percent oxalic acid electrolytic etch tests). The required laser scanning rate was calculated using the TTDS diagrams, and the theoretical thermal cycle was devised from conduction theory. They show that the complete resistance to intergranular corrosion can be restored to the surface of sensitized material by the laser treatments predicted from these calculations.

Welding High Strength Steels

IIW Document IX-1357-85 "Guide for the Welding and Weldability of Reinforcing Steels for Concrete Structures" by J. Defourny and A. Bragard (Center for Metallurgical Research, CRM, Belgium) was discussed. The steels discussed have a yield strength on the order of 500 mm. Methods to weld all types of joint geometries with GMAW, SMAW, resistance, flash, gas pressure, and thermal welding were presented.

Summary

The activities of Commission IX of the IIW are very relevant to the US Navy's research programs on welding. The European research community is coordinated to some extent (I cannot judge exactly how much) by the IIW, but the US does not participate in this organization nearly as much as does Europe (East and West) and Japan. The meetings are truly working meetings in the sense that considerable discussion and debate occurs, and much of the information presented is in the form of progress reports. Hence, one can learn of new developments or results long before they are available in the open literature.

All of the documents mentioned in this article can be obtained by writing to: Mr. P. D. Boyd, General Secretary, International Institute of Welding, 54 Princess Gate, Exhibition Road, London SW7 2PL.

11/7/86

PHYSICAL METALLURGY RESEARCH--AN EMPHASIS ON SILICON METALLURGY AT THE HELSINKI TECHNICAL UNIVERSITY

by Kenneth D. Challenger.

Background

Professor V. Lindroos' research on silicon single crystal growth at the Physical Metallurgy Laboratory of the Department of Mining and Metallurgy, Helsinki Technical University, stands out as noteworthy for the quality of the research and its potential impact in Finland.

Lindroos has been studying the techniques for the production of high quality single crystals for about 12 years. For the past 5 years this research has been strongly supported by the Ministry of Trade and Commerce and two large Finnish industrial firms, Outokumpu and Nokia. Outokumpu and Nokia are financing the formation of a new Finnish company, Okmetic, which will produce Czochralski silicon wafers by the techniques developed by Lindroos. Okmetic will become the third European supplier of these materials when it goes into production in the second quarter of 1986.

Many other research topics are also pursued under Lindroos' direction at the Physical Metallurgy Laboratory. These include: x-ray topography, high temperature deformation mechanisms, low temperature deformation and fracture, dislocation theory, dynamic recovery, electromagnetic casting, selective element corrosion, superconducting materials, nonwaste technology, constitutive equation development, and computer-aided alloy development.

Semiconductor Metallurgy

A pilot plant for the production of single crystal silicon wafers was built 1981 in the Physical Metallurgy Laboratory. Presently new buildings are being constructed in order to move the various parts of this pilot plant into one building where the necessary cleanliness can be met. At present the equipment is scattered all over the campus.

The main topics of the present studies are: (1) improvements in the methods for growing the single crystals; (2) the mechanisms of oxygen incorporation into the crystal and the behavior of oxygen during thermal treatments; (3) optimum grinding, lapping, and polishing methods for silicon wafers; and (4) optimizing the process parameters. Although little is being published at present, a great deal of research activity was evident. The project appears to be very process and production oriented; all results are held proprietary. After all, Finland will be entering this very competitive market in a few months and Lindroos' research is the foundation of this endeavor. All that I could learn from them is that research on the internal gettering of oxygen is in progress (reacting oxygen with impurity atoms and subsequently forming precipitates on dislocations present only at the centerline thickness of the wafer).

Low- and Non-waste Technology

This new program, sponsored by the United Nations, appears to be a survey of current practices and the generation of position papers on the topic. It is expected to evolve into research programs focused on reducing waste in materials production and processing. The Finns, with their love for nature, have been world leaders on this topic for years.

Brittle Fracture

The overall objectives of this research program are to determine the influence of metallurgical parameters on the toughness of bcc metals with emphasis on defining the initiation mechanism of cleavage fracture in steel.

A recently completed study is an excellent example of their research on this topic (Veistinen 1985). M.K. Veistinen and Lindroos have studied the mechanism of cleavage fracture in 26Cr-1Mo ferritic stainless steel (E-Brite 26-1). Instrumented charpy and four-point bending tests were performed at various temperatures. The fractured surfaces were examined by scanning electron microscopy and any precipitates of consequence were analyzed with their new scanning auger electron microscope (PHI-595).

The unexpected and interesting result of this study is that the cleavage cracks were initiated by fine boride particles which had precipitated on grain boundaries. While it is generally accepted that the cracking of hard particles in steels during loading at low temperatures will initiate cleavage fracture, this is the first evidence that borides could control the cleavage process. Even more surprising is that this steel contained only 0.0016 weight percent boron. A scanning auger microscope confirmed in all cases that the cracked precipitates which initiated the cleavage fracture were borides and not carbides; any carbides present were not cracked.

Superconducting Materials

R. O. Toivanen is working with Outokumpu Oy, the large Finnish copper

manufacturer, in the development of superconducting materials. The latest motivation for this research is the development of 50,000 horsepower ice breakers. The current design uses diesel engines to turn the electrical generators which then drive the propeller. In order to reduce the size of the generators, the researchers hope to design generators using superconducting wire.

The recent result of this research program is the improvement of the critical current density at 5T from 350 a/cm^2 for conventional annealed low impurity multifilamentary Nb-46.9Ti to 2860 a/cm^2 for the same material after the optimum thermomechanical treatments (it is still 580 a/cm^2 at 9T). This treatment consists of several (nominally five) cold working steps, each one followed by a 180 ks heat treatment at low temperatures (613-683°K). This treatment produces a sub-microstructure prior to the final cold working which consists of finely spaced dislocation subbands (47 nm to 88 nm wide) containing precipitates which are about 2 nm thick. After the final cold work, the subband width is reduced to 25 nm for the widest and 19 nm for the narrowest subbands and the space between the subbands contains larger elongated and small, less deformed precipitates.

Toivanen concludes that the primary factor in flux pinning is the volume of the sharply delineated subboundaries rather than the precipitates directly. The role of the precipitates is to assist and accelerate the refinement and uniformity of the subband structure.

This work is an important contribution to the understanding of the role of microstructure in superconductivity.

Computer Aided Alloy Development

K. A. Forsen is a participant in the Service Group Thermodata Europe, which is developing a data bank of thermochemical data. These data can be used in conjunction with a model developed by Professor Hillert, Royal Institute of Technology, Stockholm, to predict the phase diagrams of multi-component materials. Most of the data in the present data bank are for steel alloy development. Forsen is reviewing the literature, analyzing data and, in some instances, experimentally generating the thermochemical data to permit the same predictions for copper-based alloys.

This approach of computer-aided alloy development will save an enormous amount of time and money in the development of new alloys. It will not replace, but will guide and focus experimental studies.

The system is on-line in Europe now but, as I mentioned, is only applicable to iron-base materials.

Summary

Many research projects are in progress in the Physical Metallurgy Laboratory. The ones discussed above give a broad picture of the type of research taking place. Considerable emphasis is placed on the characterization techniques of x-ray topography, residual stress measurements by x-ray techniques, electron microscopy, and scanning auger microscopy. The projects range from very fundamental mechanistic studies (e.g., dynamic recovery mechanisms) to very applied (e.g., the production of silicon single crystals). In my opinion, the laboratory will become best known in the future for Lindroos' research on the production of silicon wafers for the semiconductor industry. Finland now seems committed to develop not only the silicon wafer technology, but to use the talents at the Helsinki Technical University to develop the entire microelectronics field, including every step in the process which starts with the production of pure silicon from its ores and ends with the tools for use in the development of artificial intelligence.

Reference

Veistiner, M.K., and V.K. Lindroos, "Cleavage Fracture Strength of a 26Cr-1Mo Ferritic Stainless Steel," *Journal of Heat Treating*, 4 (1985), 56-68.

11/8/85

Physics

A CONFERENCE ON GUIDED OPTICAL STRUCTURES AND THEIR APPLICATIONS

by Paul Roman. Dr. Roman is the Liaison Scientist for Physics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on assignment until September 1987.

The North Atlantic Treaty Organization's Advisory Group for Aerospace Research and Development (AGARD) organized a meeting entitled "Guided Optical Structures in the Military Environment."

The conference took place within the framework of the 37th Symposium of the Electromagnetic Wave Propagation Panel of AGARD, held from 23 through 27 September, 1985 in Istanbul, Turkey.

There were about 80 invited registrants. The overwhelming majority of the participants came from North America. The UK, West Germany, Italy, and France were also well represented. Thirty-five half-hour talks were given, all in open, full plenary sessions. Each talk was followed by a short, often lively, question-and-answer period, and each major group of presentations was concluded by a scheduled 30 minutes of discussions. Generally speaking, these discussion sessions were slow-going and did not contribute much except for a chairman's summary.

A few days before the conference, AGARD published its *Conference Preprint No. 383*, which contains fairly detailed texts of the talks. The complete, edited *Conference Proceedings* will be available this spring. Both documents are easily available through the usual, appropriate AGARD documentation centers; thus, there is no need for ONR London to publish a formal conference report. For the same reason, I will keep this informal article rather brief, selecting topics according to my personal taste. However, interested readers can get copies of the selected talk abstracts from me, as well as the list of all talks and the list of all participants.

I should mention at the very beginning that the title of the conference was perhaps slightly misleading. Overwhelming emphasis was given to fiber optics; other guided systems and devices, as well as nonlinear optical phenomena were mentioned only sporadically. This may be explained by the fact that, despite the many fiber optics conferences that take place these days, the last AGARD meeting which dealt with such topics was held in 1977. An incredible new technology has arisen since then: single-mode structures operating at 1.3 μm and beyond; fibers with attenuation below 0.5 dB/km and bandwidth in the range of hundreds of GHz; new passive devices, such as sensors detecting almost anything and almost reaching the theoretical detection limit; active components like single-mode, high efficiency, long-life laser chips operating at room temperature; and a host of nonlinear devices and aids for optical research. The richness of these discoveries and their imaginative combination have far-reaching military applications, both tactical and strategic. Rapidly deployable tactical communications, undersea surveillance systems, fiber-optic sensors (such as gyroscopes, hydrophones, and magnetometers), and optical computing are the most obvious examples. Therein lies the importance of the AGARD meeting: it brought together many leading experts from academia, industry, and the military who endeavored to share and unify the advanced technologies of their respective activities.

The talks could be grouped into the following broad areas:

- Fiber optic sensors
- Fiber optic communications and tactical lightwave technology
- New fibers for mid- and far-infrared ranges
- Various devices and techniques.

I shall now very briefly indicate highlights in each group.

Fiber Optic Sensors

The keynote address, a penetrating review of optical fiber sensor technology, with special emphasis on the effects of laser noise and of demodulation techniques on performance, was delivered by T. G. Giallorenzi. Since he is the superintendent of the US Naval Research Laboratory's Optical Services Division, there is no need for us to go into details here. I was particularly impressed by his optimistic assessment of the possibility of joining hundreds of different kinds of sensors by multiplexing and other techniques into a single local area network telemetry system.

Four papers dealt with fiber optic gyroscopes. I found the one by E. Udd, S.F. Watanabe, and R.F. Cahil (McDonnell Douglas Astronautics Co., Saint Louis, Missouri) the most illuminating: ring laser and fiber-gyro technology was compared, and the current status of applicability of these "competing" devices was compared (see Figure 1). One interesting conclusion was that digital fiber-optic gyros (discussed to some extent in a talk by B. Culshaw, University of Strathclyde and J.D. Nuttal, Ferranti plc.) probably can beat laser gyros in the future.

Another unusual paper in the area of optical fiber gyroscopes was from the Central Research Laboratories of Thomson-CSF, Orsay, France; it was coauthored by H. C. Lefevre, J. P. Bettini, S. Vatoux, and M. Papuchon. These authors described in a long and unusually lucid paper a very compact (1/4-liter volume) fiber-gyro that uses a multifunction integrated optics circuit (splitter, polarizer, and phase modulator), a super-luminescent diode, and 250 m of polarization-holding fiber. The device is now in the "brass-board" stage

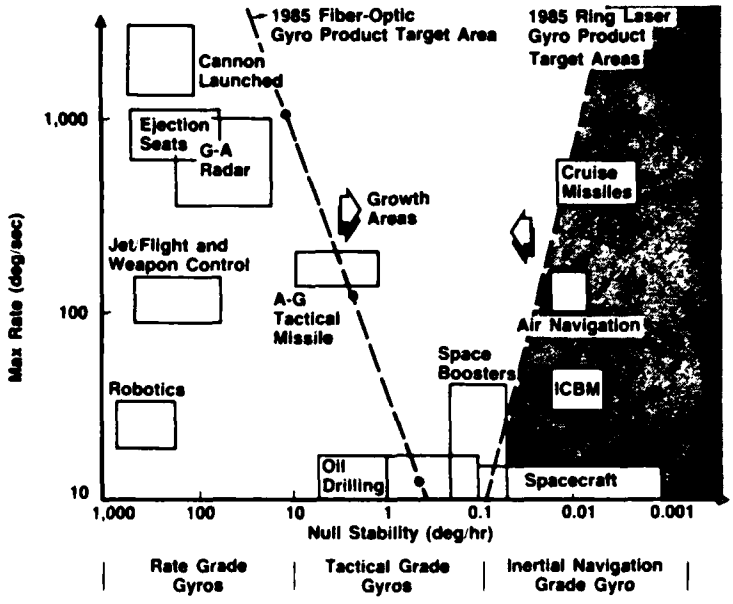

Figure 1. Comparison of laser- and fiber-optic gyro applicability areas, 1985.

of development. It should be noted that a simpler, but also very compact gyroscope from Thomson's caused unusual interest in July 1985 at the Munich Laser Trade Fair.

J.P. Dakin and C.A. Wade (Plessey Electronic Systems, UK) described progress they have made in developing a time-division-multiplexed fiber optic hydrophone array which used optical time domain reflectometry techniques. One of the major problems they solved was the fabrication of low-loss, partially reflecting joints. They emphasized that there is an optimum value for the required reflection; this, in turn, depends on the number of sensors in the array. Dakin and two other scientists from Plessey (C.R. Batchellor and J.A. Rex) also reported on magnetic (and pressure) sensors that use a compensated polarometric configuration. Good sensitivity and better stability than is possible in more conventional interferometric systems has been achieved. Finally, Dakin and P.B. Withers (also from Plessey) presented a related study of two possible methods of phase-noise reduction of semiconductor lasers for sensor applications.

Nonlinear ellipse rotation in a low-birefringence optical fiber was the topic of a talk by an Italian academic cooperation (B. Crosignani, S. Trillo, P. di Porto, and S. Wabnitz). I found this work interesting because it considered the role of the nonlinear Kerr effect.

Fiber Optic Communications and Related Topics

The leading talk in this area was given by S.D. Walker and associates (British Telecom Research Laboratories, UK); he reported progress made during the last 18 months in optical transmission system experiments, investigating long distance span (90 to 250 km) and wide bandwidth transmission, with line rates from 34 Mb/s to 2 Gb/s, at the 1.5-μm wavelength region. The talk analyzed a variety of configurations and options.

In the discussion, attention was called to the fact that, in military applications, high bandwidth is not the only paramount goal. Indeed, some other conference presentations explored different concerns. For example, M. Aslam (Shape Technical Center, The Hague, The Netherlands) discussed the performance of fiber-optic transmission systems when they are exposed to radiation following a nuclear explosion. K.H. Niederhofer and W.D. Schuch (Messerschmitt-Bölkow-Blohm, Munich, West Germany) compared the performance of single-mode fibers and graded-index multimode fibers in applications where the fiber link is used for missile guiding. They came to the somewhat tentative conclusion that, for missile ranges over 10 km, single-mode fibers should be favored for optical, mechanical, and radiation-resistance reasons. S.S. Cheng (Bell Communications Research, New Jersey) also reached this conclusion when considering

a hybrid transmission scheme for tactical communications.

Two papers considered the use of light-wave technology in future radar equipment designs, and, more generally, in connection with microwave/millimeter-wave fiber-optic systems. Both talks were by American authors (C.M. Gee and colleagues at Hughes Research Laboratories, California, and J.J. Pan from E-Tek Dynamics, Florida, respectively). They discussed situations where extremely-high-frequency modulation/detection in optical transmission systems is the goal (as opposed to the more familiar analog transmission at audio or video frequencies).

New Fibers for Longer Wavelengths

The chairman of this session, J. Lucas (Rennes University, France) opened the discussions by reminding the audience of the three areas that call for going beyond silica-glass fibers: achieving ultralow losses, such as 10^{-3} dB/km, in the 1- to 3-μm range; sensor applications in the 2- to 12-μm atmospheric window range; and power delivery (for CO, CO_2, HF lasers). He also neatly grouped possible solutions to achieve these goals:

1. Hollow waveguides
2. Glasses:
   a. Halide glasses
   b. Heavy-element oxide glasses
   c. Chalcogenide glasses
3. Crystalline fibers:
   a. Poly-crystalline-material fibers
   b. Single-cystal fibers

At the AGARD conference, contributions were presented only in the areas of halide glasses, chalcogenide glasses, and single-crystal fibers. Indeed, in the keynote address D.C. Tran reviewed recent pioneering work and progress done at the US Naval Research Laboratory on ZrF_2 glasses. AS Tran pointed out, his talk was primarily drawn from the published literature, including NRL reports, and it provided a complete review of the present state-of-the-art in the field. However, Lucas in his session-concluding talk again took up the topic of fluoride glasses, and described the intensive work done in his laboratories at the University of Rennes. He noted many other possibilities beyond the MF_2 glasses with M = Zr, for example, M = Be. He talked about MF_3 glasses with M = Fe, Cr, Ga, In, Al, Pb, Mn; and about MF_4 glasses with M = Zr, Th, U. As a special case, he emphasized that a ZrF_4 + BaF_2 composite, or even more multicomponent glasses, seem to exhibit higher stability than MF_4 or MF_2 types. Thorium-based quaternary glasses were also considered. Lucas pointed out that Th-Zn fluoride combinations are potentially superior to ZrF_2 glass in the 5-μm range. Another point of his talk that caught my attention was the description of his laboratory's technique called "reactive atmosphere processing," where the application of CCl_4 and CS_2 eliminates the disastrous OH impurity (from quaternion melts).

The work of N.J. Pitt and M.G. Scott (Standard Telecommunication Laboratories Ltd., Harlow, UK) reported on their very exciting experiments with chalcogenide glasses for transmission in the 8 to 12-μm range. They concentrated mainly on the Ge-As selenide and on the As selenide-telluride types. They succeeded in producing fibers several hundred meters long, with a pulling rate of 5 to 10 m per minute, and with 50- to 500-μm diameters. When protected by an epoxy-acrylate coating, significant strength increase is shown by the fibers, and they can sustain a bending radius of about 1 cm. Losses in fibers based on Ge-As-Se are currently below 10 dB/m at 10 μm. However, the authors believe that the As-Se-Te systems are more promising, and with further improvement in purification and oxide gettering techniques, offer the possibility of an order of magnitude reduction in losses.

Finally, S. Feigelson (Stanford University, California) talked about the emerging single cystal fibers. Apart from materials science aspects, his talk reflected on the growing research with such fibers in the field of nonlinear optics (such as extremely efficient up-conversion or mixing) and the construction of fiber-lasers.

Devices and Techniques

By their very nature, these sessions were inhomogeneous to a very large extent, and therefore my reporting will be even more eclectic. Concerning the great variety of devices that are currently considered in the area of guided optical structures, the chairman of the session made two interesting comments. One was that, despite the exciting basic discoveries of the past few years and the successful laboratory demonstrations of novel devices, the road to military applications of these achievements is still very bumpy. The other remark, which came up in the final discussion session, was this: The enthusiastic efforts leading hopefully to full optical computing should be looked upon with a great deal of skepticism; on the other hand, partial use of optical methods, such as for busing in huge electronic

parallel computers, is very near to practical exploitations.

Now, a few selected items.

Wavelength-division multiplexing (WDM) recently attracted much worldwide interest. Indeed, the first talk in the session (which I now consider) was in this area. It was presented by J. Hegarty (Trinity College, Dublin, Republic of Ireland) and reported on work done in cooperation with two groups of the AT&T Laboratories in the US. My special interest in this presentation is that it described the first successful single-fiber transmission system with more than 1 terabit km/s capacity. The feat of such an ultra-high transmission rate (over a distance longer than 68 km) in a single-mode fiber was achieved by closely spaced WDM of 10 distributed feedback lasers. The remarkably simple diagram of the arrangement is shown in Figure 2. (Actually, 22 in-fibers and one out-fiber are shown; but until now only 10 inputs were used, simply because of space limitations on the experimental board.) The lasers operated around 1.5 μm (they were selected from a large sample) and were modulated at 2 Gb/s. The multiplexer channel spacing was 1.35 nm. The demultiplexer was basically identical to the multiplexer, but used in reverse. Practically error-free (less than 10^{-9} BER) operation was demonstrated. It is worth pondering that the demonstrated breakthrough corresponds to a value of 21 million voice channel-kilometers.

Another interesting talk on WDM was presented by the IROE group of Florence, Italy (V. Russo, S. Sottini, G.C. Righini, and S. Trigari) who described calculations and preliminary experiments on a multiplexer-demultiplexer (MUX-DEMUX) device based on a spherical geodesic lens used as a focusing element, i.e., a waveguide lying on a quarter of a sphere. Besides acting as a MUX-DEMUX device, it can also operate simultaneously as a DEMUX and tapping element.

Other highlights of the sessions considered were the reports from the Optical Sciences Center, University of Arizona. First, G.I. Stegeman gave an impressive review of recent conceptual progress in nonlinear planar guided-wave interactions and devices. Obviously, these studies are crucial to the goal of all-optical processing of optical signals. In a related talk from the same group, we heard about detailed calculations and preliminary experiments on two different passive, low-power, guided-wave optical limiters.

In the area of optoelectronic broadband switching for communication

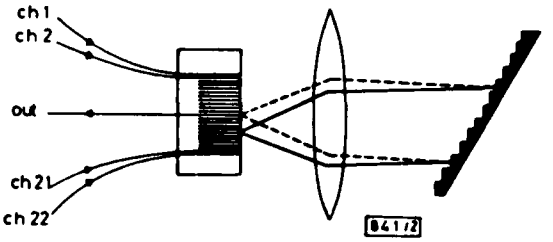

Figure 2. The multiplexer.

and signal processing, a Canadian group (Communications Research Centre, Ottawa) appears to have reached a leading position. The interesting point in the paper by R.I. MacDonald and D.K.W. Lam was that they had demonstrated high optical isolation levels in monolithically integrated optoelectronic switch matrices--without the need to actually switch light. They employed a hybrid technology, using electronic and optical integration.

Finally, I should mention the work of B.N. Schwaderer (ANT Nachrichtentechnik, Backnang, West Germany). He described the design of a hybrid integrated p-i-n field-effect transistor transimpedance preamplifier for long-haul optical transmission systems, operating at 1.3 μm, with rates of 140 Mb/s and 565 Mb/s, respectively. The preamplifier uses a GaInAs/InP p-i-n photodiode. At BER less than 10^{-9}, sensitivities of -42.8 dBm and -35.8 dBm respectively (including connector losses) have been already achieved.

Concluding Remarks

I believe this was a very useful conference, a relaxed meeting that brought together high-level specialists, and where the urgent need of technology transfer between the more and the less developed members of the NATO community was well served. Despite the somewhat heavy emphasis on fiber optics, there was a reasonable balance between areas. Generally speaking, the conference was systems-oriented rather than technology- or device-focused.

11/5/85

OPTOELECTRONICS RESEARCH AT OXFORD UNIVERSITY

by Paul Poman.

The huge Department of Engineering Science at Oxford University incorporates a small but competent unit, often referred to as the Holography and

Integrated Optics Group, which has been led for a number of years by a dynamic scientist and one-time microwave-engineer, Professor L. Solymar. Even though the group operates in frontier areas and publishes a great deal in international journals, they do not seem to have much contact with American scientists and I find it useful to give a brief report on some of their recent research activities which caught my imagination. The topics include wave mixing, integrated optics, and holographic electrooptics.

Wave Mixing in Photorefractive Materials

Photorefractive crystals have been studied for some years with a view to various applications in the field of real-time optical data-processing. One of the promising materials is bismuth silicon oxide $Bi_{12}SiO_2$ (or BSO, for short) which allows for fast response and high index modulation in wave-mixing experiments. Large values of exponential gain in two-wave mixing have been observed, and if the amplified signal is fed back to the BSO, various oscillators can arise in which the frequency of the beam is spontaneously shifted. These phenomena were the basis of Solymar's recent research, done in collaborations with colleagues at the Thomson-CSF Central Research Laboratories at Orsay. The central idea of this work is the insight that the high-gain wave-mixing experiments are based on the recording of a moving interference pattern in the volume of the crystal. This can be interpreted as a "drift" recording mode with an externally applied field. In the theoretical part of the study, the scientists studied the solutions of the so-called Kukhtarev equations with a moving grating and demonstrated a resonance effect which, at the optimum grating velocity and spatial frequency, makes the space charge field higher. This allows efficient beam coupling in nearly degenerate two-wave mixing and four-wave mixing experiments. Several such experiments (such as image amplification, laser beam steering, ring resonators, phase conjugate resonators, amplified phase conjugation) have been performed and analyzed. Good agreement between theory and experiment was established; further work will involve adequate control of several additional crystal parameters.

Resonant Cavity Sensor With Integrated Optics

Dr. R.A. Syms, an ambitious junior scientist in the group, is engaged both in holography and integrated optics. One of his just-concluded projects considers the design of interferometric sensors fabricated on a single integrated optic chip and to be used in a multiplexed system. He observed that a multiple-pass interferometer using a resonant cavity should be extremely attractive because it has a large path imbalance which can be easily varied. He then analyzed the detailed behavior of a resonant cavity sensor and computed response curves under a variety of conditions. Actual experimental work was carried out specifically with temperature sensors fabricated in $LiNbO_3$. These sensors were based on two different imbalances in the $LiNbO_3$. Even though the finesse was poor (due to high losses), the sensitivity of the devices was found to be extremely high. For example, operating at 1.15μm wavelength, a device of length 13.5 mm had a sensitivity of better than 1.8°C per oscillation, and the fringe visibility was 0.19.

Syms is now engaged in a rather different enterprise: he is studying optical directional couplers equipped with a grating overlay.

Holographic Grating for Achieving Single-Mode Semiconductor Laser Operation

Long-distance high-data-rate transmission over fibers at the minimum attenuation point of 1.55 μm requires either dispersion shifting in single-mode fibers or the application of single-mode 1.55-μm lasers, or still better, a combination of both. Since single-mode diode laser fabrication is still not an easy job, P. Mills (in cooperation with R. Plastow at Plessey Research) set himself the goal to develop a novel technique for achieving single-mode laser behavior. In his device, the diffracted light from a holographic volume grating provides a source of external feedback for the semiconductor laser. The hybrid device incorporates the feedback selectivity of a distributed grating without sacrificing the high yield of a laser fabricated by the standard procedure. It has been demonstrated before that external gratings (and the use of waveguides) can stabilize the laser wavelength. However, the production of the volume holographic grating proposed by Mills has, amongst other things, the advantage that it can be fabricated in a much simpler way: the procedure involves only a simple exposure and a fixing step.

In his careful work Mills with Plastow demonstrated that adjacent-mode suppression better than 16 dB can be achieved. The success of the device is well illustrated by Figure 1.

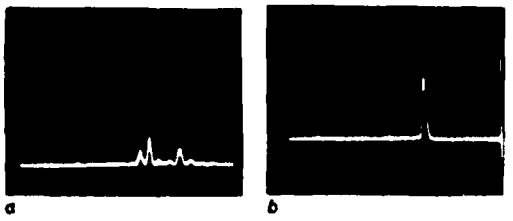

Figure 1. Mode spectrum of laser: (a) without, and (b) with external feedback.

Concluding Note

This brief article covers only three of the many areas of current research by the Oxford Engineering Science research group. Since this survey is so highly selective, it cannot do justice to the work these scientists are doing. But I hope it will foster better contacts by American scientists with this group of predominantly young researchers who are working in many advanced areas of modern optics.

10/31/85

OPTOELECTRONICS RESEARCHERS OCCUPY AN ISLAND IN THE VENETIAN LAGUNE

by Paul Roman.

General Introduction and Some Highlights

The 5th International Conference on Integrated Optics and Optical Fiber Communication, cojoined with the 11th European Conference on Optical Communication, was held 1 through 4 October, 1985, on the Venetian island of S. Giorgo Maggiore. The conference was organized by the Istituto Internazionale delle Communicazioni, in cooperation with six Italian industrial foundations. The meetings were sponsored by the Convention of National Societies of Electrical Engineers of Western Europe, in liaison with several American, Japanese, and international professional societies.

Over 1000 scientists, engineers, technician, industrialists, government officials, and businessmen gathered at this mammoth convention. Contributions to the program came from 16 countries, and many more nations were represented (including some belonging to the Warsaw Pact and from the People's Republic of China (PRC)). There were 24 half-hour long invited papers; an incredible 279 scheduled and an additional 16 post-deadline contributed papers (15 minutes each), and 30 poster presentations.

The topics covered were divided into three broad categories, and the presentations were run in three parallel sessions. The talks were grouped as follows:

- Fiber optics and optical communication
- Lasers and systems
- Integrated optics, waveguides, and sensors.

The majority of the talks concerned fibers and cables, closely followed by optoelectronic devices and by communication systems. Integrated optics, nonlinear phenomena, and sensors played, numerically, a minor role. However, I want to point out that despite the relatively low number of presentations in these areas, several novel and interesting talks were given on nonlinear waveguides and related optical devices.

Compared with previous conferences in the series, there was a very prominent increase in the number of papers on optoelectronic devices, probably indicating both the maturity of the field and a rapidly increasing commercial need. Particularly worth noting was the increased number of contributions on distributed feedback laser diodes and on distributed Bragg reflector devices. Apparently, spectacular success has been achieved with these devices, especially by Japanese researchers who quite obviously dominated the field. (In this day-long session, eight Japanese papers, and only one paper each from France, West-Germany, and Sweden was presented.)

Ultrahigh speed devices also commanded much interest. Reports of advances in this area were spread out over several sessions, so it is difficult to give a fair assessment of the leaders in the field. But wavelength division multiplexing and other rapidly growing techniques associated with both old and new devices were also given a full day's correlated attention in two sessions. If the number of contributors (and the liveliness of discussions that followed their presentations) is a good measure of leadership, the UK has a strong lead. Japan, the US, and West Germany follow closely.

Not unexpectedly, coherent optical communication systems commanded lots of attention. In the two sessions devoted to these topics the UK and Japan were equally represented, but there was very little contribution from other countries.

For many people, a highlight of the meeting (in contrast to previous conferences) was the announcement by scientists from the Japanese NEC Cooperation of the first successful, complete monolithic integration of a complex optoelectronic device: an InGaAsP/InP DFB-laser, two high-speed MISFETs, and a detector were integrated on one substratum. This circuit showed a modulation bandwidth of 4GHz, and 2Gb/s random pulse modulation was achieved. Other semi-integrated circuits also caused considerable interest.

List of Sessions

I should emphasize that the preceding discussion aimed only at pointing out areas of more rapid development than others, but in no way reflected the absolute number of papers given in the three covered fields. Perhaps it will be useful if I now list the titles of sessions that were held in the 3 fields into which the conference contributions were grouped.

Fiber Optics and Optical Communication
New materials and processes
Fiber fabrication
Polarization in single-mode fibers
Dispersion-optimized fibers
Fiber characterization
Single-mode fiber properties
Optical cables
Wideband subscriber loops
Single-mode fibers in the subscriber loop
Subscriber loop and LAN technology
Optical networks
High speed systems
Single-mode systems

Lasers and Systems
DFB laser diodes
DFB-DBR laser diodes
Optical amplifiers
Laser diodes (general developments)
System technology
Coherent optical systems
Coherent transmission technology
Multi-quantum-well structures
Photo detectors
Advanced laser diode structures
Noise in semi-conductor lasers
Frequency control of laser diodes
Linewidth in single-mode lasers

Integrated Optics, Waveguides, Sensors
Integrated optical waveguide fabrication
Optical waveguide devices
Integrated optics waveguide components
Nonlinear and nonreciprocal integrated optics devices
Optoelectronic integrated circuits
Waveguide optical switches
Optical interconnects and switching
Fiber coating and related topics
Single-mode couplers and WDM devices
Coupling and WDM
Topics on future optical communications
Sensors
Sensors and special applications

Concluding Remarks

The major message of this unusually large convention was that optoelectronics research, as a whole, is moving away from optical communication and is seriously attacking problems of optical information processing. Another significant feature was the aggressively strong attack of Japanese scientists on crucial topics. A final observation is that intensive research is directed to achieving what may be justly called the "ultimate physical limits" of performance in a variety of components and devices based on quantum optics and quantum electronics.

The conference had many shortcomings, mostly because there were too many participants and attempts were made to cover too many research areas. This attempt led to a proliferation of overspecialized contributed papers but did not serve the purpose of satisfying all interests. The overcrowding in the (beautiful and well equipped) lecture rooms was most disturbing. While people who knew each others' work surely had a chance to talk to each other (if they skipped lectures and walked around in the cloisters) I do not think that there was sufficient time or opportunity for proper interacting. Quite frankly, and at the risk of sounding iconoclastic, I feel that such overgrown meetings are mainly self-serving.

By the date of the conference the organizers had published the detailed and illustrated "Proceedings" of the talks in three volumes, consisting of a total of 1220 pages. These proceedings may be purchased for LIT 80,00 from the Istituto Intenazionale delle Communicazioni, Via Pertinace, Villa Piaggio, I-16125 Genova, Italy. For these reasons, I do not see the point in writing a formal ONR conference report. But I will be glad to supply individual scientists with a list of all talks and speakers in any category listed above, and then send a copy of specific abstracts for personal use.

The conference was accompanied by a small, well-organized exhibit by Italian firms involved in fiber optics communication. The brief catalog describes the activities of these establishments. This also, I can supply.

10/11/85

FRACTAL CONFERENCES IN EUROPE

by Michael F. Shlesinger. Dr. Shlesinger is a Scientific Officer in the Physics Division, Office of Naval Research, Arlington, Virginia.

Although Benoit Mandelbrot (IBM and Harvard) has been working on the subject of fractals for some thirty-five years, he only coined the term in 1975, when he felt the subject had become ripe enough to be given a name. To help celebrate this tenth anniversary--and Mandelbrot's sixtieth birthday--three major international fractal conferences were held this summer at the Institut d' Études Scientifiques de Cargese (Corsica), the International Center for Theoretical Physics in Trieste (Italy), and a Gordon Research Conference in Antrim, New Hampshire (US). This attests to the interest in and rapid growth and popularity of this new field. Ten years ago the word fractal did not exist; today it is hard to find a copy of, for example, the *Physical Review Letters* without some discussion of fractals. (For a previous article on fractals by Dr. Shlesinger see "Fractals in the Physical Science", *ESN* 38-9:500-503 [1985].)

Fractals--Objects With No Characteristic Scale

Fractals are geometric objects which possess an infinite number of features of different sizes or, in other words, they possess no characteristic scale. Some scattered old examples of deterministic (or non-random) fractals are the Appollonian gasket, the Weierstrass function, and the Koch curve. The Weierstrass function, for example, has wiggles upon wiggles on all scales and is nowhere flat, which causes this everywhere-continuous function to be nowhere differentiable. Such examples were considered to be pathological and most certainly not to have any physical significance. Mandelbrot's classic 1967 paper in *Science*, "How Long is the Coast of Britain? Self-Similarity and Fractional Dimension," drastically changed this view. Mandelbrot's latest book *The Fractal Geometry of Nature* (Freeman, 1982) offers us a new paradigm that most of the geometry arising in nature is fractal and not Euclidean. In the case of a coastline the answer to what is its length is, "it depends." It depends on what scale you observe. Finer and finer scales reveal more and more details and lead to longer and longer lengths of the coastline. If a change of scale by R reveals N new features where only one was observed before then the curve of the coastline can be ascribed a fractal dimension, greater than unity, $D_F=\log N/\log R$, or reminiscent of an equation for a volume $N(R)=R^{D_F}$. The length of the coastline is infinite because the curve is really more than one-dimensional.

Another example of a fractal curve is Brownian motion. The trajectory is a curve, but is so wiggly that it fills up the plane. The Brownian trajectory has dimension 2 which is greater than the coastline dimension which is between 1 and 2.

Many new examples of fractals have been discovered and analyzed in recent years including the surface of clouds, the infrared radiation intensity curve as a function of distance along a cloud, the surface of porous catalysts, soot particles, fractal Brownian motion, the space in which turbulence is concentrated, niobium-germanium cluster sputter deposited on quartz substates, colloidial silica aggregates, a gel at the gelation point, polymers in good solutes, clusters in critical phenomena, percolation clusters, invasion percolation patterns, viscous fingering, event times for electron hopping in amorphous materials, and on and on. After a fractal conference one gets the feeling that it is difficult to find real objects which (over some range of sizes) are not fractal.

Many people believe that all fractals are self-similar; that is, a finer resolution reveals essentially the same features but on a smaller scale. At the Trieste meeting, Mandelbrot discussed a class of fractals, generated by a multiplicative process, which are self-affine but not self-similar. A random process $B(t)$ is self-affine if $B(t)$ and $b^{-H}B(bt)$ are identical in distribution for all $b>0$. The case $H=1/2$ is Weiner's scalar Brownian motion with independent and stationary Gaussian increments. Note that the rescaling of t and B are different, so many notions such as dB/dt are meaningless in this self-affine geometry. For a point moving in the (x,y) plane Mandelbrot studies the record of self-affine processes which are the sets of points (t, x(t)) and (t,y(t)) rather than the set of all points visited (x,y). He finds the situation for calculating a fractal dimension to be complicated. For a global method, the value 1 is found, so globally the record behaves as if it were not a fractal. Local methods, such as calculating the number of boxes needed to cover the record, yield the dimension 2-H, while walking a compass (open to a fixed small angle) along the record yields the dimension 1/H. Only for the value H=1 do these different

methods for calculating a dimension coincide. The main thrust of this lecture was that while there has been an explosive growth in the study of fractals many basic issues are still untouched, particularly in regard to self-affine fractals.

Let us then restrict ourselves to self-similar fractals where a fractal dimension can unequivocally be determined. Does this completely characterize the fractal? This question was, in part, the topic of the lecture by Gene Stanley (Boston University) at the Cargese meeting. He discussed 10 different (but not independent) dimensions which can be useful for characterizing a random fractal. The usual fractal dimension D_F is a measure of how many points (or how much mass M(R)) and within a radius R of an origin; i.e., $M(R) \sim R^{D_F}$. One can also consider the mean square displacement $\langle R^2(N) \rangle \sim N^{2/d_w}$. For Brownian motion, the fractal random walk dimension $d_w=2$, and d_w is larger than 2 for walks on fractal structures. Other fractal dimensions involve the backbone of an infinite cluster (all dangling bonds removed), the hull of a cluster (only points which can be reached from outside of the cluster), and the minimum path length between two points on a fractal cluster. If one doubles the distance between two points, the minimum path will much more than double because this tortuous path is fractal. Antionio Coniglio (Universitá di Napoli) showed than an infinite set of exponents can be generated to describe a fractal which are related to the voltage distribution across a network of resistors with the same structure as the fractal. Let N(V) be the number of bonds which have a voltage V across them. The quantity $\Sigma V^k N(V)$ diverges as L^{D_k} where L is the cluster size (which goes to infinity) and D_k defines this exponent. D_0 is the fractal dimension of the backbone; D_2 is related to the resistance, D_4 to the noise characteristics, and D_∞ to the number of single backbone bands which when cut would break the cluster into two separate parts. Thus, even the question of how to characterize the structure of and dynamics on a statistical self-similar fractal is open and a matter of great interest and debate.

The Cargese Conference

This conference, "On Growth and Form: A Modern View," was organized by Gene Stanley and Nicole Ostrowsky (Université de Nice) as a NATO Advanced Study Institute (27 June through 6 July 1985). There were 11 principal lecturers and 22 seminars. The main question was how does nature create the multitude of shapes and forms which are fractal? Hans Hermann (Saclay) described a variety of growth models in the spirit of critical phenomena using the ideas of scaling laws. The differences between growth models and static models (such as the Ising model), both of which have fractal clusters, was also discussed.

Hermann concentrated on idealized irreversible growth models (which did not involve thermodynamics or optimization criteria) including the Eden model, diffusion-limited aggregation (DLA) epidemics, mole's labyrinth, and clustering of clusters. Some of the models grow clusters by adding one particle at a time, but each by a different rule. Alla Margolina (DuPont) discussed a variety of rules for the growth on the perimeter of a cluster which she termed butterfly, ant, and caterpiller rules. The Eden model (introduced by M. Eden in 1961) adds one particle at random to any random perimeter site; although the perimeter is rough the cluster itself is not fractal. Deepak Dhar (Université de Paris, Pierre et Marie Curie) proved that even though the Eden cluster is basically circular in two dimensions, in some higher dimension it must be asymmetric. The DLA model (introduced by T. Witten and L. Sanders in 1981) has a single particle diffuse to perimeter sites on a cluster. Bumps which initially form from statistical fluctuation tend to grow because they present a larger target for the diffusing particles than other perimeter sites. Bumps soon grow and develop new bumps on their sides, and so on until a fractal dendritic structure is formed. The growing dendrites shield inner perimeter sites from being reached, causing the DLA structure to not have a homogeneous structure.

Robin Ball (Cavendish Laboratory) analyzed the DLA process and gave examples of DLA found in experiment, including the electrodeposition of copper in a copper sulphate solution, the electrodeposition of zinc metal in an interfacial layer, viscous fingering, and in patterns of dielectric breakdown. Tom Witten (EXXON) discussed variants of the DLA model, and raised suspicions that anisotropic properties of the DLA cluster may arise in larger size simulations than have so far been achieved. This would imply that our knowledge of DLA is far from complete.

One of the major highlights of the meeting was the work of Harvey Scher and Lee Turkevick (SOHIO) on calculating the fractal dimension of DLA and other structures. Usually, one just counted

the number of particles in a cluster as a function of a radius from a chosen center. This yielded a fractal dimension but gave no insight into the reason for any particular number. Why in 2D is the DLA dimension about 5/3? Scher and Turkevick noticed that the DLA structure in 2D could be placed roughly into a square. They then made an exact analogy between the DLA problem and the calculation of the electric field lines for a square held at a fixed potential enclosed by a surface at infinity. Long dendritic arms have a high probability of being struck by a diffusing particle in the DLA, and equivalently sharp corners have a strong electric field in the electrostatic problem. The manner in which the field line strength diverges at corners was related to the fractal dimension of the DLA. The results between this theory and simulations were not inconsistent and were, in fact, in good agreement. The DLA shape is, however, not really a square with four corners, but has a Cantor set of singularities. Leo Kadanoff and Tom Halsey (University of Chicago) have discussed a formal procedure to take into account the true complicated set of singularities in the DLA problem. This research promises to be a most fruitful and exciting endeavor in the area of fractal growth process. On a cautionary note, surface tension effects can round off sharp edges and destroy a cluster's fractal behavior.

Hermann continued with a discussion of epidemic models where a cluster perimeter site is chosen at random either to die or to become a growth site and make its neighbors available for the same selection process. This generates a fractal structure which possesses holes of all scales and looks quite different from DLA.

In the DLA picture one particle at a time diffuses until it is attached to the initial seed or other particles which have previously stuck to the seed. If all the particles can act as seeds then many clusters will form. If these clusters can move and stick to each other then a cluster-cluster aggregation process is created. Simulations have shown this process generates fractal shapes which mimic gel formation.

Another highlight of both the Cargese and Trieste meetings was the film by Max Kolb (Université de Paris-Sud and Freie Universität Berlin) which showed the time evolution of the Eden model, the DLA model, and the cluster-cluster aggregation model.

The cluster-cluster aggregation model generates a shape of dimension 1.75. The experimental work of Dave Cannell (University of California at Santa Barbara) using light scattering techniques found the dimension 2.08 for clusters of colloidal silica particles in .5M NaCl. However, in 1M NaCl both 2.08 and 1.77 dimensional clusters can be found. In the .5M solution the kinetics are slow and the largest clusters settle out during the course of the experiment; while for 1M the kinetics are fast and more closely resemble the rules of the cluster-cluster aggregation model and yield a dimension close to its prediction by simulation. The best simulation work for a variety of models has been done by Paul Meaken (Dupont). It is Meaken's values for dimensions that theorists strive to predict.

Dale Schaefer (Sandia National Labs), using dynamic light scattering techniques, found several materials to have a fractal structure, including colloidal silica in solution, vapor aggregates such as Cab-O-Sil™ (used, for example, in paint), and colloidal powders with a high surface area such as carbon black. Jose Teixeira (Laboratoire "Leon Brillouin", Saclay) lectured on scattering experiments designed to probe fractal structures. Examples included dimensions of 1.65 for proteins and 2.6 for immunoglobulin aggregates.

Many other topics were discussed by the lecturers. Dietrick Stauffer (Universität Koln) gave an enlightened and humorous review of percolation clusters. See his new book *Introduction to Percolation Theory* (London: Taylor and Francis, 1985). Francois Leyvraz presented a rate equation approach to aggregation phenomena. David Landau (University of Georgia at Athens) discussed within a kinetic model the percolation and non-percolation-like properties of gelation. Fereydoon Family (Emory University) described theoretically the time-dependent kinetics of aggregation models using a dynamic scaling theory and the Smoluchowski equation. One could see his predictions visually verified in the movie shown by Kolb. Etienne Guyon (Études Scientifiques Physique et Chemie Industrielle) examined the relationship between flow and form in random materials. He pointed out many experimental results that are not explained by existing models. One example was that even in a well-connected media the flow characteristics varied significantly within a single pore. He discussed a theoretical connection in poorly connected geometries between critical exponents for the elasticity and electrical conductivity of a lattice which did not agree with experimental results. Jorge Willemsen (Schlumberger) also lectured on flow through a porous media. He emphasized

how one fluid can displace another (invasion percolation) of a different viscosity. In the limit of an infinite viscosity ratio, DLA-like shapes appear.

Jean-Pierre Boon (Université Libre de Bruxelles) analyzed the development and growth of patterns arising from reaction-diffusion models.

The extremely well-organized organizers extracted manuscripts from all the speakers before they left Corsica. Therefore, I need not cover all of the details of the lectures as the proceedings should soon appear as *On Growth and Form: A Modern View*, ed. H.E. Stanley and N. Ostrowsky (Martinus Nijhoff, Pub. 1985).

The Trieste Conference

The same diligence was shown by L. Pietronero (Rijksuniversiteit Te Groningen), the chairman of the organizing committee of the Sixth International Symposium *Fractals in Physics*, of the International Center of Theoretical Physics in Trieste, 9 through 12 July 1985. The proceedings of the Trieste meeting should soon appear as a North-Holland publication. While the Cargese meeting stressed growth mechanisms which lead to fractal structures such as coagulation, flocculation, polymerization, agglutination, gelation, and aggregation, the Trieste meeting provided a more general view of fractals.

Thirty-five lectures and forty-eight posters were presented. I will just highlight a few of these presentation and direct the interested reader to the proceedings for a complete review of the conference.

Robin Stinchcombe (University of Oxford) concentrated his lecture on the topic of dynamical processes on fractal structures. He discussed how random walkers, phonons, and spin waves move on random and deterministic fractals. Dhar found the number of eigenmodes for an Eden cluster to vary as the square of the frequency, as opposed to the exponent D=Euclidean dimension, as is expected for compact objects.

Peter Pfeifer (Universität Bielefeld) analyzed experiments where a rough surface is covered by a monolayer of molecules. The experiment is then repeated in sequence for smaller and smaller molecules. The manner in which the number of molecules in the monolayer increases determines the fractal dimension of the surface. This gives a new method for characterizing materials used as heterogeneous catalysts.

E. Louis (Universidad de Alicante) introduced a model based on the propagation of fracture zones which generate fractal fracture patterns in materials. A piece of the material breaks down and loses its elastic properties if the stress acting on it exceeds a critical value. In a certain limit, the theory reduces to the model of dielectric breakdown of Niemeyer, Piertronero, and Wiesmann where Laplace's equation is solved continuously, as the breakdown regions grow, and the probability distribution for further growth directions is calculated. Dielectric breakdown patterns closely resemble the DLA structure.

H. Takayousu (Kyoto University) showed for a similar model of a network, in a different limit, that the fracture and dielectric breakdown will be quite different, with the fracture propagating much more slowly.

Sara Solla (IBM) also discussed a breakdown mechanism, via a renormalization group approach, leading to stress buildups which can cause earthquakes.

Franz Rys (Fritz-Haber Institute) analyzed radar data from large hail clouds and found surfaces of dimension 2.4 in agreement with earlier observations of S. Lovejoy and D. Schertzer (Meteorologie Nationale, Paris), who discussed the effect of anisotropic inhomogeneous turbulence in determining the shape of clouds. The anisotropy is important for distinguishing between horizontal flows and striated vertical flows. For smaller clouds in strong lateral winds a sharp crossover to nonfractal clouds was found in Rys' analysis.

Theo Geisel (Universität Regensburg) showed how one-dimensional maps can generate a fractal set of time scales. For a near-tangent bifurcation within a unit cell the trajectory can remain at nearly the same position for many iterations. When averaged over all initial conditions, a probability distribution for the time elapsed for the trajectory to remain nearly localized can be calculated. The possibility for waiting times of all lengths to occur, including very long waiting times, leads to an intermittent diffusion process whose mean square displacement grows sublinearly with time. This has been called a fractal time process. Jacob Bernasconi (Brown-Bovari) showed how such behavior can also be derived from a real space renormalization procedure in a random media. Alex Blumen (Max Planck Institut-Mainz and Technische Universität Munchen) discussed the transport and reaction of random walkers on lattices (periodic and fractal) whose movements are a fractal time process. The number of distinct sites visited by a walker (and thus the reaction rate) depends both on the fractal time

dimension and the spectral dimension of the lattice. The spectral dimension is independent of the fractal dimension. It governs the number of distinct sites visited in N steps. The fractal time dimensions govern how long it takes to make N steps. The author, with Jossi Klafter (EXXON), reviewed three theories of dielectric relaxation in disordered materials--the Forster direct transfer model, the hierarchial constrained dynamics model, and the defect diffusion model. The last model postulates that mobile defects carrying free volume eventually reach frozen-in dipoles and provide them sufficient room to reorient and relax. A key ingredient is that the defect motion is governed by a fractal time distribution. When this occurs the ubiquitious Williams-Watts stretched exponential decay law, $f(t)=\exp(-t^x)$, with x less than unity, is derived as a probability limit distribution for the dipole-dipole correlation function.

By allowing the tangent bifurcations to occur outside of a unit cell, Geisel was able to change the localization time in the tangent region to a laminar time over which the trajectory is transferring smoothly between unit cells. The laminar time distribution leads to a mean square displacement growing as t^2 (accelerated diffusion). This model has been applied to analyzing the 1/f noise in voltage phase oscillation in Josephson junctions. The author with Klafter developed fractal random walk models which, for different space-time scalings, give a mean square displacement proportional to t^2, t^3, or t^{3+y}. These cases are related to intermittency in a Josephson junction, Richardson's law for homogeneous turbulent diffusion, and fractally-intermittent turbulent diffusion. This work was reported at Cargese.

In another lecture on dynamics, Predrag Cvitanovic (University of Chalmers) analyzed the universal properties of fractal devil's staircases for the mode-locking regimes of circle maps.

The last lecture of the conference was also on the subject of dynamics. Arnold Mandell (University of California at San Diego) brought forth the idea that fractal chaos in biological oscillator systems implies a flexibility to interact with the external environment. Frequency locking limits the system to only a few select frequencies which would poorly match the 1/f noise inherent in the environment. Specific examples of sick and aging biological systems losing their 1/f noise matched with the appearance of frequency locking were given for several biological indicators such as EKG and heart interbeat intervals. The excitement generated by this talk points to biological dynamical systems as a new and rewarding frontier for the physical scientist. A conference on nonlinear biological dynamics will be held at the National Institute of Health in April 1986. Details can be obtained from the author.

Fractals--A Revolution in Science

The growth of the field of fractals has been tremendous in the last five years. The fractal concept has been one of the great unifying factors in science helping to reverse the trend of specialization. Physicists, mathematicians, chemists, biologists, meteorologists, geologists, and engineers all sit together at fractal conferences and speak the same language. This in itself is a great accomplishment. Fractals along with chaos and solitons have sparked a revolution in science which I believe will rank alongside quantum theory and relativity. These meetings show that we are in the midst of this revolution and that this late twentieth century is an exciting period in which to be a scientist.

11/26/85

News and Notes

ONRL EDITOR LEAVES

This is the final issue of the *ESN* to be edited by Dr. Larry E. Shaffer. Over the past three years Larry's outstanding editorial leadership has lead to many changes in the *ESN*'s content and in the publication process. He leaves a memorial: a high quality and dynamic publication with a distribution list of over 5000. We will miss Larry at ONRL. We have said our goodbyes to Larry, but once again we wish him success in his new job at Battelle, Columbus.

David L. Venezky
12/13/85

SIGLE--JOINT EFFORT OF EUROPEAN DOCUMENTATION CENTERS

SIGLE--System for Information on Grey Literature in Europe--is an on-line bibliographic service with the documents themselves available through a designated national center in each participating country. Grey literature includes report literature, discussion and policy documents, working papers, conference papers, theses, some official publications, supplementary data, local government publications, etc. It is essentially nonpublished material normally unavailable from any predictable source.

SIGLE covers the fields of science, technology and, most recently, the humanities and social sciences. Main subject groups are: aeronautics; agriculture; plant and veterinary science; humanities; psychology and social sciences; biological and medical sciences; chemistry; earth sciences; electronics and electrical engineering; computer science; energy and power; materials; mathematical sciences; mechanical, industrial, civil, and marine engineering; methods and equipment; military sciences; missile technology; navigation, communication, detection and countermeasures; ordnance; physics; propulsion and fuels; and space technology. Current holdings are 80,000 documents with an anticipated annual increase of 25,000 records.

The system is accessible through Euronet--DIANE, the European Economic Community's (EEC's) communications network. US users can access SIGLE through the British Library Lending Division's online bibliographic service BLAISE. Inquiries should be directed to: Marketing and Support Group, The British Library, Bibliographical Services Division, 2 Sheraton Street, London W1V 4BH; telephone (UK, London) 1-636-1544, ext. 242/284. Search costs are £27 per hour plus the annual subscription rate of £45. Telecommunication costs are not included. On-line users will find it useful that SIGLE is searchable by country.

Input into SIGLE is announced in *British Reports, Translations and Theses*, published by the British Library Lending Division, Boston Spa, Wetherby, West Yorkshire LS23 7BQ, UK. It is available by subscription at £52.00.

National authorities are in Belgium, West Germany, France, Great Britain, and Ireland. Associated institutions are in Italy, Luxembourg, The Netherlands, Sweden, and the EEC (Office for Official Publications of the EEC). SIGLE became operational in January 1981. It is a cooperative venture of the Commission of the European Communities and the British Library Lending Division.

Donna L. Mott
US Air Force
European Office of Aerospace
Research and Development
12/2/85

BUILDING A NEW MOLECULAR ELECTRONICS RESEARCH CENTER AT OXFORD UNIVERSITY

Professor Garreth Roberts, formerly at the University of Durham, UK, occupies a new special chair at the Department of Engineering Science, Oxford University. He is building up a major research center for the exciting and, at least in England, rapidly growing science of molecular electronics. While transferring his equipment from Durham and outfitting a whole floor-full of new laboratories, Roberts still maintains his second position of chief scientist at Thorn EMI. He also presides over a UK government committee charged with coordinating nationwide activities in molecular electronics.

The major technology Roberts and his coworkers use is Langmuir-Blodget film deposition (for a review of this technique and some previous work done in this area, see Robert's review article in *Advances of Physics*, No. 4 [1985]).

Their current and planned work concentrates on two areas: organic transistors, and nonlinear organic devices.

In the first area, Roberts has succeeded in producing the organic equivalent of a metal oxide semiconductor device (which consists of a metal film, an organic insulator film, and a silicon substrate) where the organic deposit consists only of one, two, or three molecular layers, as designed. These transistors (suitable, for example, as supersensitive and almost instantaneous response sensors for specific chemicals) are superior, Roberts claims, to any similar device available.

Roberts' second major line of research focuses on the construction of nonlinear organic microelectronic devices. In order to produce, by the Langmuir-Blodget process, an organic layer that has large nonlinear coefficients it is necessary to coat the substrate with alternating mono-molecular layers of two different chemicals, so that the antialigned dipole moments do not cancel pair-wise and that a nonsymmetric field ensues. Rogers achieves

this with a special Langmuir trough that has two isolated halves, separately regulated. The substrate sample, in the shape of a cylinder, is immersed at the meeting point of the two trough-halves, and rotates (along a horizontal axis) rapidly. In this way, alternating ordered layers of the two different organic molecules build up, and films of 10- to 100-nm thickness can be constructed in minutes.

Examples of nonlinear devices of this kind are pyroelectric, acoustoelectric, ferroelectic systems, and devices for second harmonic generation. Roberts has already achieved international renown by building the first pyroelectric infrared organic film imaging device. This organic nonlinear transistor, called "pyrofet", consists of a Si substrate, a pyroelectic organic film that is 100nm to several hundred nanometers thick and a metal top film. Infrared light penetrating through the metal film affects the transistor properties by affecting the pyroelectric organic film. The major features of this discovery have been recently submitted for publication in *Electronic Letters*. However, because of proprietary reasons, the actual chemical composition of the two alternating organic molecules is not divulged, nor will other specific details of their current and planned work.

Paul Roman
10/30/85

EUROPEAN ATOMIC SPECTROSCOPY CONFERENCE IN JULY 1986

The 18th conference of the European Group for Atomic Spectroscopy (EGAS) will be held at Philipps-Universität in Marburg, West Germany, from 8 through 11 July 1986. Theoretical and experimental aspects of the spectroscopy of atoms and small molecules will be covered. Applications to other fields (including astrophysics), instrumentation problems, and other topics related to atomic physics will also form part of the program.

A special feature planned is a 1-day scientific excursion to the Heavy-ion Research Institute near Darmstadt. This excursion will provide an opportunity for participants to visit laboratories built around the UNILAC accelerator and hear talks on exotic atoms and related topics.

The deadline for registration is April 15. Abstracts for papers (or poster-presentations) will be accepted until June 1.

All correspondence should be addressed as follows: 18th EGAS, Attn: Dr. M. Elbel, Fachbereich Physik, Philipps-Universität, D-355 Marburg, West Germany. Telex: 482372 UMR.

Paul Roman
10/24/85

INRIA HOSTS NAVIER-STOKES WORKSHOP

The Institut National de Recherche en Informatique et en Automatique (INRIA) hosted a Gesellschaft für Angewandte Mathematik und Mechanik (GAMM) Workshop on Numerical Simulation of Compressible Navier-Stokes Flows in Nice, France, from 4 through 6 December, 1985. The organizing committee, representing the GAMM Committee on Numerical Methods in Fluid Mechanics, included representatives from INRIA, P & M Curie University, Société Avions Marcel Dassult-Bréguet Aviation, Nice University, and the Office National d'Etudes et de Recherches Aérospatiales (ONERA). The objective was to bring together a small group of scientists actively working on the solution of the compressible Navier-Stokes equations.

The workshop focused on numerical methods that have been developed for the simulation of two-dimensional, steady flows. The goal was to compare the predictions obtained for various numerical simulations with experimental data. Of particular interest was the accuracy and efficiency of existing numerical methods in the transonic flow regime. To exclude all sources of discrepancy due to turbulent modeling, only laminar flow cases were considered. The ultimate objective of this workshop was to contribute to the development of efficient basic tools needed by the scientific and industrial communities for the solution of more complex problems, including both the phenomena of turbulence and combustion.

One internal and one external problem were proposed. Working one of the two test problems was required for participation in the conference. For both problems the fluid was assumed to be a perfect gas with a constant ratio of specific heats of 1.4. The viscosity and thermal conductivity were assumed to be constant and the Prandtl number was assumed to be 0.7.

The first problem, external flow, was a symmetric NACA 0012 airfoil with the surface temperature equaling the free stream total temperature. Seven test cases were identified for which four were mandatory and three were optional. These cases included Mach numbers of 0.8, 0.85, and 2.0; angles of attack of 0 and 10 degrees, and Reynolds numbers which ranged from 73 to 10,000.

The second problem was the flow in a plane-symmetrical dual-throat nozzle (Figure 1). The geometry consisted of two contiguous convergent/divergent nozzles preceded by a constant area approach section. The wall geometry was given by five polynomial arcs of continuous slope. The height of the second throat was 30 percent larger than that of the first. The flow in the first nozzle was assumed to be choked and the wall temperature assumed to be equal to the reservoir temperature. There were three mandatory test cases which ranged in Reynolds number from 100 to 1600 based on the half-height of the first throat.

For both test problems, detailed specifications of the manner in which the results were to be presented were provided. Plots of density, Mach number, pressure, and temperature contours as well as velocity components, distributions of wall pressure, sheer stress, heat flux, and details of the computations including storage requirements, convergence history, mesh, and computational time were requested. Demonstrations of grid sensitivity were also requested.

A preliminary list of participants included individuals from the US, England, Belgium, Australia, Italy, France, Austria, India, Israel, Canada, Sweden, Greece, and Japan. Papers presented at the workshop will appear as a bound proceedings to be published by F. Vieweg & Son. Questions concerning the meeting should be directed to Dr. M.O. Bristeau, INRIA, Domaine de Voluceau, Rocquencourt BP 105, 78153 Le Chesnay Cedex, France.

Eugene F. Brown
11/22/85

THE THIRD INTERNATIONAL CONFERENCE ON IMMUNOPHARMACOLOGY

Immunopharmacology is a relatively new area of focused research and has its roots in drug suppression of inflammatory diseases and organ transplant recipients. Although much effort is still being made to find more effective and less toxic drugs for these conditions, the immunopharmacologists represented at the Third International Conference, in Florence, Italy, 6 through 9 May 1985, have a positive outlook on pharmacological manipulation of the immune system. In recent years, the role of the immune system in preventing infections and cancer has become better appreciated. As we gain a better understanding of how the immune system is regulated, potential targets for amplifying rather than suppressing its activities become apparent. The state-of-the-art is rather primitive with regard to drugs that up-regulate rather than down-regulate the immune response; these drugs are variously termed immunopotentiators, immunostimulators, or immunomodulators (which cover both stimulation and suppression). However, several compounds are now in various phases of testing by drug firms. Much of this work was reported in Florence, along with extensive discussions of the potential targets for new drugs (which constituted the substance of the

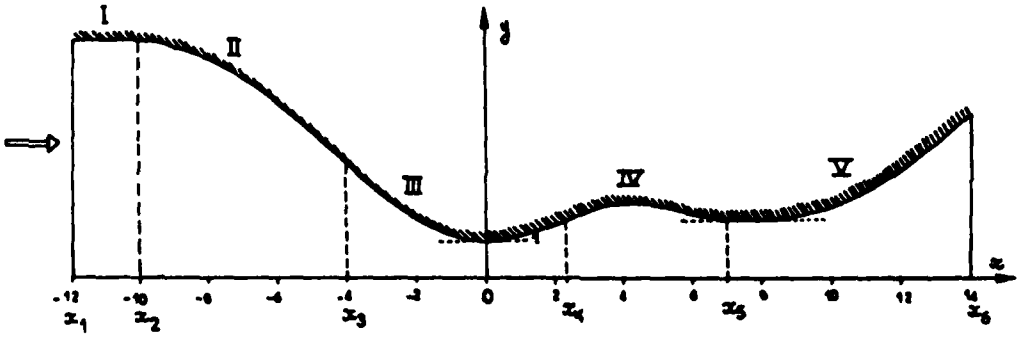

Figure 1. Dual-throat nozzle.

symposia--the actual drugs were primarily discussed in poster sessions). A total of eight symposia were conducted on molecular and cellular mechanisms of immune regulation, and 28 poster/workshops discussed current developments in individual drugs. Three special lectures provided historical overviews of the field. Approximately 400 participants registered, primarily representing European and Japanese centers of research, the predominant sources of immunopharmaceutical development at this time.

Areas of immunopharmacology of particular interest to military medicine include adjuvants (helpers) for vaccines, and stimulants of nonspecific resistance. The need for vaccine adjuvants, which are routinely used in animal studies to boost immune responses, has been greatly increased by new developments in vaccine design. While living-agent vaccines (such as yellow fever or oral polio) do not require adjuvants for effectiveness, and killed whole organism vaccines (such as typhoid or cholera) provide their own adjuvants via the microbial products they contain, the highly purified protein or peptide vaccines currently being developed lack good intrinsic immunogenicity. Extensive work is going on in France, largely at the Institute Pasteur, and in Japan, primarily at Osaka University, on a synthetic mycobacterial cell wall product called muramyl dipeptide (MDP) that is highly immunostimulatory. While the original MDP is quite toxic, numerous derivatives have been tested and two appear to be of low toxicity and high efficacy: murabutide from Institute Pasteur and threonyl-MDP from Syntex, Inc. Both are undergoing clinical trials.

Stimulants of nonspecific resistance are intrinsically more complex because of the numerous targets that can be manipulated. Most work has been done with stimulants of interferons. These are paracrine hormones that were originally studied for their antiviral activity. To date, no efficacious interferon inducer that is not too toxic for humans has been discovered, and current studies, primarily in cancer patients, are using interferons produced directly by recombinant DNA techniques. Very limited efficacy has been found to date.

Other components of nonspecific host defenses that have been targeted are the phagocytes, primarily the macrophage. There are a number of microbicidal mechanisms available to these cells that could be activated by drugs. Several microbial products, such as endotoxins, have this action as well as polysaccharides and synthetic polyanions. However, progress in this area is slow. One product under development which probably works via this mechanisms is a lipophilic derivative of MDP, called MTP-PE, from CIBA-GEIGY. This material is active at the mucosal surface and induces resistance to numerous viruses for several weeks; however, reproducibility of this phenomenon is still a problem.

Most stimulants of nonspecific resistance have been found by accident rather than by design as more and more drug firms are screening drugs routinely for effects on immune responses. One new discovery by this route is a piperidine derivative called LF 1695 from Laboratoire FOURNIER in Dijon, France. This compound stimulates maturation of T lymphocytes much like thymic hormones. It appears protective in both infections and autoimmune models and is under active development for human use.

No startling new developments were reported at the Florence meeting, but the potential for a major breakthrough comparable to penicillin continues to tantalize workers in this field. It remains to be seen if the promise of the immune system as a manipulable instrument for control of disease will be met.

Jeannine A. Majde
Office of Naval Research
11/4/85

ONRL COSPONSORED CONFERENCES

ONR, London, can nominate two registration-free participants in the conferences it supports. Readers who are interested in attending a conference should write to the Scientific Director, ONRL, Box 39, FPO New York 09510.

The Contractile Mechanism of Smooth Muscle, 11-15 March 1986, Maria Alm, Austria.

Growth Factors in the Nervous System, 24-26 March 1986, Kent, UK.

International Optical Computing Conference, Jerusalem, Israel, 7-11 July 1986.

Sixth International Symposium on Gas Flow and Chemical Lasers, Jerusalem, Israel, 8-12 September 1986.

SCIENCE NEWSBRIEFS FOR NOVEMBER & DECEMBER

The following issues of *Science Newsbrief* were published by the ONR, London, Scientific Liaison Division during November and December. *Science Newsbrief* provides concise accounts of scientific developments or science policy in Europe and the Middle East. Please request copies, by number, from ONR, London.

Science Newsbrief Number	Title
3-53	Finland Sets Up Silicon Wafer Plant, by Kenneth D. Challenger.
3-54	Fluid Mechanics Meetings in Europe for 1986, by Eugene F. Brown.
3-55	Unique Electrophoretic Separator Developed in the UK, by Claire E. Zomzely-Neurath.
3-56	The European Composite Forum Has Been Created, by Kenneth D. Challenger.

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NOVEMBER MAS BULLETINS

The following *Military Applications Summary (MAS) Bulletins* were published by the ONR, London, Military Applications Division during November. The *MAS Bulletin* is an account of naval developments in European research, development, test, and evaluation. Its distribution is limited to offices with the US Department of Defense. DoD organizations should request copies of the *Bulletins*, by number, from ONR, London.

MASB Number	Title
124-85	A Fire Retardant Cableway
125-85	Australian Submarine Corporation, Pty. Limited
126-85	Non-Cryogenic Nitrogen Generator System
127-85	Escape, Survival and Rescue at Sea--Call for Papers
128-85	New Technology Helmet Display/Sight System by Elop of Israel
129-85	Infrared Sensor Cyrogenic Cooling Using Stirling Cycle Principle
130-85	Shipboard Noise Monitoring Equipment
131-85	Small Arms Trainer
132-85	Lightweight Airborne Self-Protection EW System from Elisra of Israel

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ONRL REPORTS

To request reports, indicate the report number on the self-addressed mailer and return it to ONR, London.

C-11-85 *Quantum Electronics in the UK: A National-Survey Conference*, by Paul Roman. The Seventh National Quantum Electronics Conference met from 16 through 20 September 1985 in Great Malvern, UK. This report highlights presentations on lasers, nonlinear optics, and quantum optics.

C-12-85 *Seventh European Immunology Congress, Jerusalem, Israel*, by Claire E. Zomzely-Neurath. The Seventh European Immunology Congress was held in Jerusalem from 8 through 13 September 1985. This report focuses on presentations dealing with interferons and interleukines; immunoregulation; immune, endocrine, and neural systems correlations and interactions; immunodeficiency; as well as immunomodulation and immunopharmacology.

C-13-85 *Biotechnica'85: 1st International Congress for Biotechnology, Hannover, West Germany*, by Claire E. Zomzely-Neurath. This report provides a review in some detail of the presentations in the three general areas of the topics: measurement of process control and development of models; biocatalyst preparation, utilization, and improvement; and animal and plant cell cultures. The report concludes that the excellent presentations showed that biotechnology research in Europe and the UK is of high caliber and represents a greatly increased emphasis on basic as well as applied research in biotechnology.

C-14-85 *State-of-the-Art Survey of Gyrotron Research: ONRLWS*, by Paul Roman. The workshop/survey held at King's College, London, UK, on 25 through 26 November 1985 included presentations from the US, the UK, Continental Europe, and the Middle East. This report gives brief coverage of all the presentations, and focusses, in particular, on areas of controversy in both theory and method.

C-15-85 *The Damage Tolerance of Carbon Fiber Reinforced Composites--A Workshop Summary*, by Kenneth D. Challenger. The workshop in Glasgow, Scotland held on 12 September 1985 included participants from the US, the UK, Australia, and France. This report discusses six critical problem areas associated with damage tolerance of carbon-fiber reinforced composite materials: damage tolerant materials, testing methods, structural life prediction, damage tolerant design concepts, repair methods, and nondestructive testing.

R-6-85 *Immunology Research in Israel*, by Claire E. Zomzely-Neurath. Research in immunology has developed and flourished greatly in Israel. Initially, research in this area was carried out primarily at the Weizmann Institute of Science, Rehovot. In the late 1960s and 1970s, new academic centers were established for immunological research at universities in Tel-Aviv, Haifa, and Be'er Sheba. Important areas in immunology research being pursued by Israeli scientists include investigation of immunoglobulin genes, structure-function analysis of antibodies and regulation of antibody production and expansion; genetics of autoimmunity and cancer; lymphokines and complement; autoimmunity; tumor immunology; transplantation and tissue typing; clinical immunology; infectious diseases; and applied immunology.

R-7-85 *Summary of European Feedback Control Research*, by Charles J. Holland. Feedback control will continue to be an important research area in Europe as well as internationally. This is not only because of applications in traditional areas, ranging from (perhaps mundane) boiler and industrial control to missile guidance, but also because of newer applications areas in robotics and distributed systems such as flexible space structures. This report covers research on feedback control in The Netherlands, the UK, West Germany, and Sweden.

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